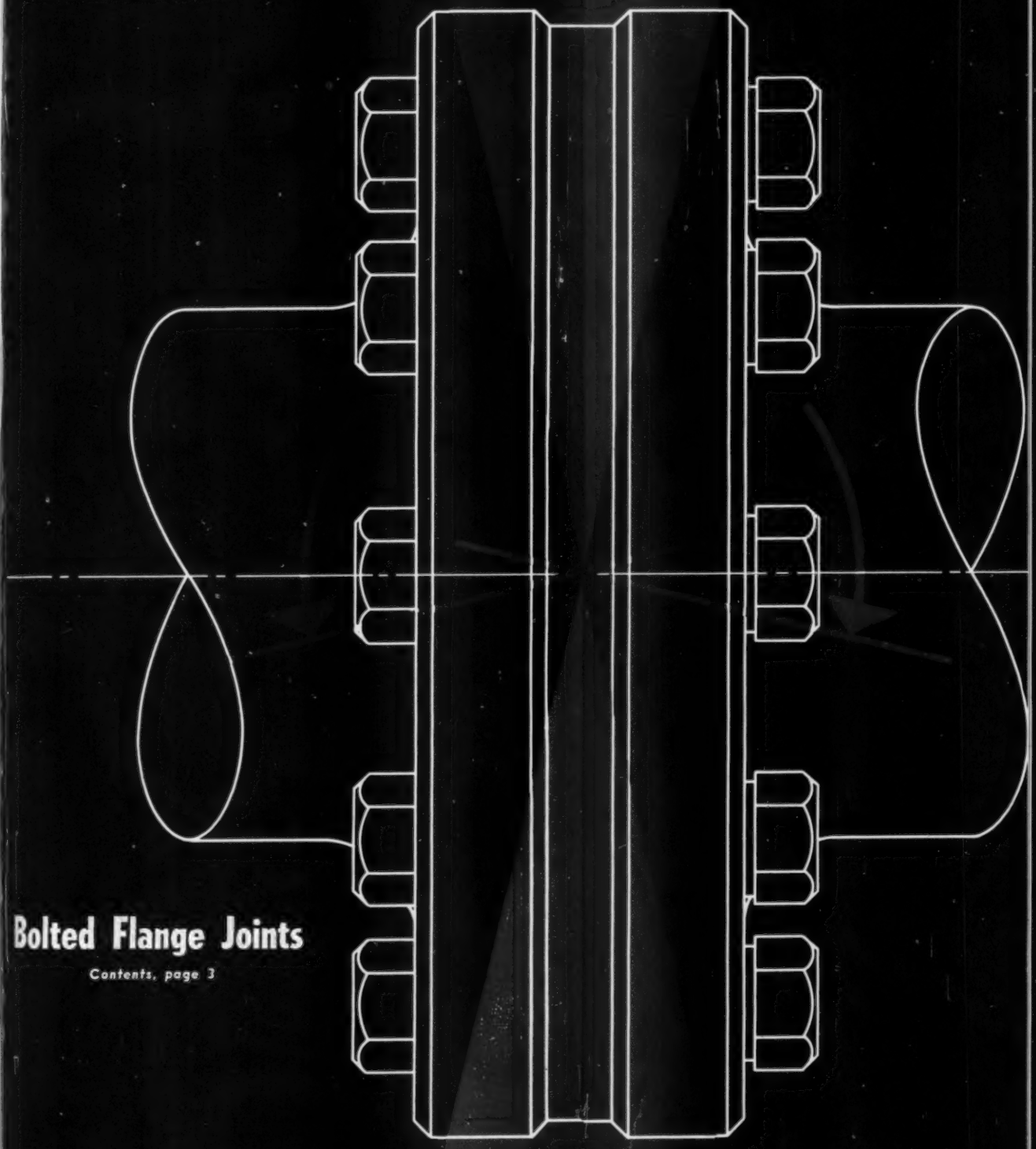
NOVEMBER 15, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Bolted Flange Joints

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XUM

Solve Bearing Space Limitation Problems

WITH

NORMA-HOFFMANN

EXTRA LIGHT

XLS Series Precision Bearings

Advantages

- **Have unusually large bores compared to outside diameter**
- **Provide utmost in accuracy, rigidity, and load capacity — (radial and thrust)**
- **Are compact, light in weight**
- **Allow greater freedom in design. In many cases these bearings provide the only solution where space is at a premium.**

Norma-Hoffmann "XLS" *Extra Light Inch* Series Ball Bearings provide engineers and designers the advantage of high anti-friction performance plus space saving. They are ideal for hollow shafts.

These bearings are self-contained, non-separable and are suitable for combined radial and thrust loads in either direction. They are available in sizes from 1⅜" to 22½" bore. Our Field Engineers will gladly help you with your bearing problems. Write for their assistance and catalog.

NORMA-HOFFMANN *Precision* **BEARINGS**

BALL • ROLLER • THRUST

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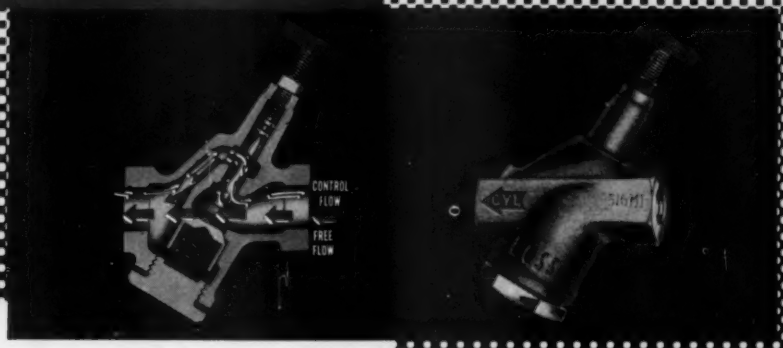
Founded in 1911 · **STAMFORD, CONNECTICUT**

FIELD OFFICES:

Atlanta • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Kansas City • Los Angeles • Philadelphia • San Francisco • Seattle

Circle 501 on page 19

cylinders act right!

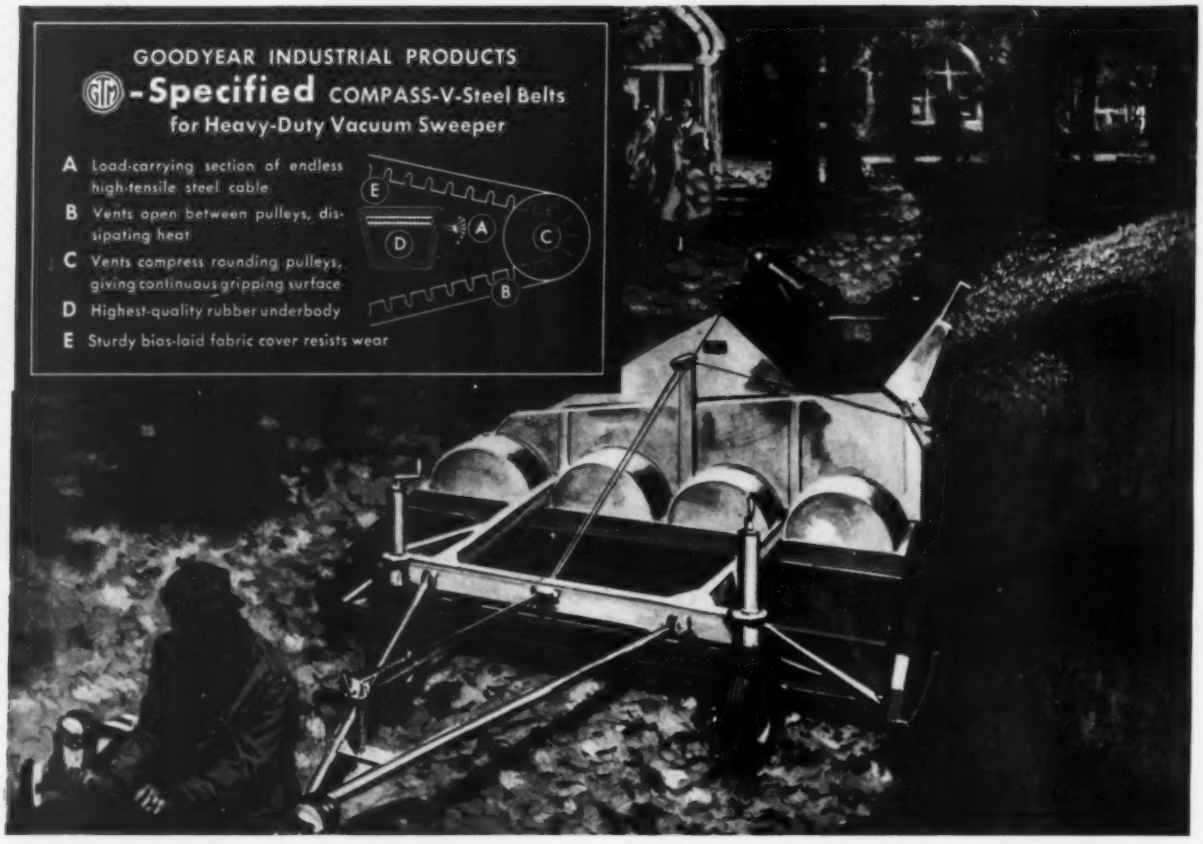


Cylinders act right with Ross speed controls

Mount the Ross Speed Control valve in any position between the operating valve and the cylinder—the exact air flow you need is precisely measured through. Positive adjusting and easy to maintain, the valve's only moving part is its poppet. Available in ¼", ⅜", ¾", 1" and 1¼" sizes.

Ross A galaxy of new air-control stars are coming your way from
OPERATING VALVE COMPANY
109 E. GOLDEN GATE AVE • DETROIT 3, MICHIGAN

Circle 504 on page 19



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It's 1952. You're a manufacturer of heavy-duty vacuum sweepers and you've got a problem.

Out in your plant is a big, new tractor-drawn unit that will remove and mulch leaves and litter from as many as 25 to 30 acres per day. That is, provided you can find a V-belt to handle the 25-h.p. 2000-r.p.m. drive.

On this drive, you have one four-groove drive pulley and four separate driven pulleys. To operate efficiently, the belts must be perfectly matched and must stay that way. So far no belt tried has turned the trick.

Finally, you ask the G.T.M.—Goodyear Technical Man—for help. He studies the drive and recommends COMPASS-V-Steel belts muscled with airplane-type steel cables. You put them on the drive and the machine on the market.

Today, you're still using the G.T.M.'s belts and in almost *four years* haven't had a *single complaint.* What's more, the G.T.M. is your No. 1 Counselor on any industrial rubber problem. You contact him often through your Goodyear Distributor or Goodyear, Industrial Products Division, Akron 16, Ohio.

COMPASS-V-STEEL BELTS by

GOODYEAR

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Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

November 15, 1956
Volume 28—No. 23

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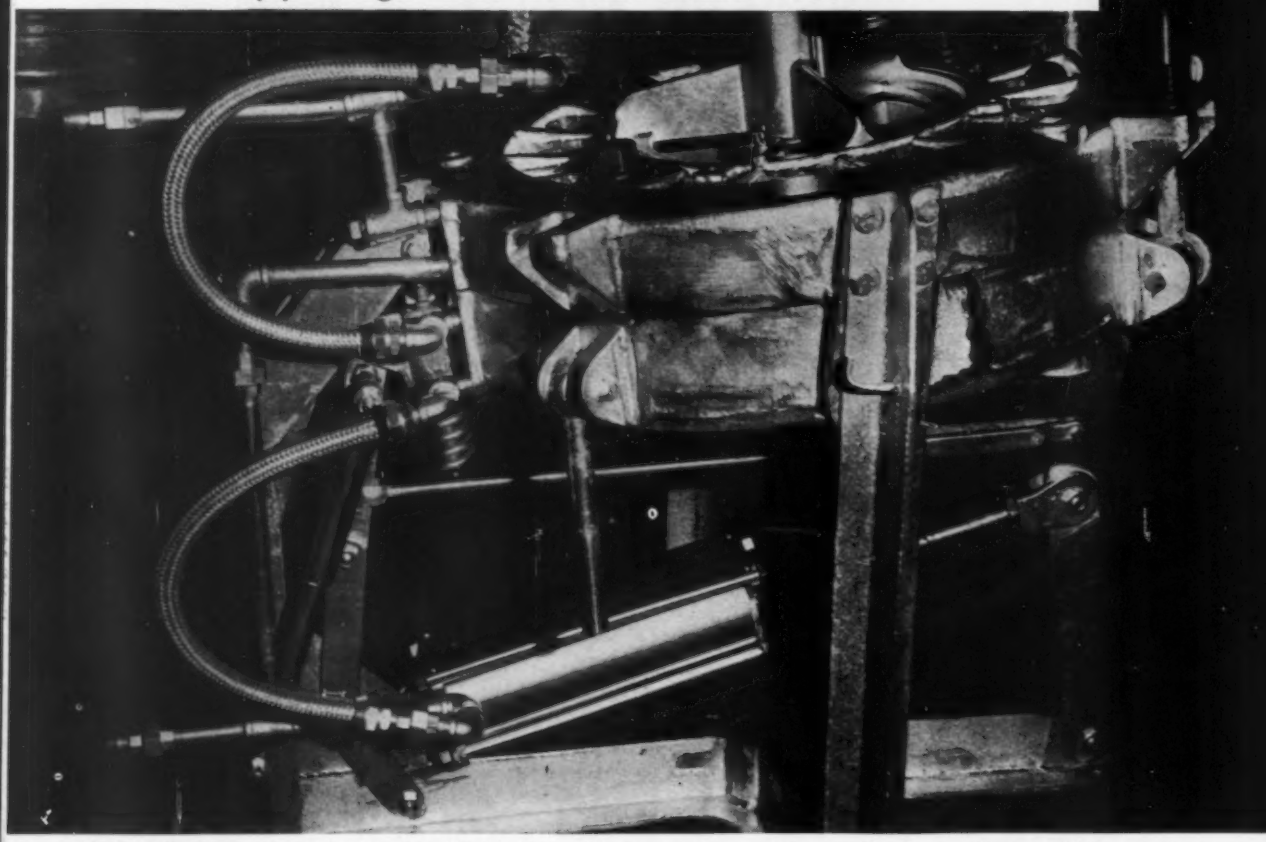
XUM

Where your problem is pipe that must flex

reduce pipe fatigue with American flexible metal hose



300°F, 50 lb. pressure is met by American Flexible Bronze Hose connecting moving steam chambers on Super Mold tire capping equipment.

"American flexible metal hose is tops for trouble-free service!" says C. R. Lohr of the Super Mold Corporation. Since 1940, American flexible metal hose has been conveying steam between moving parts on Super Mold tire capping equipment.

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5618

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VIBRATION

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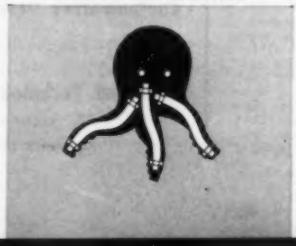
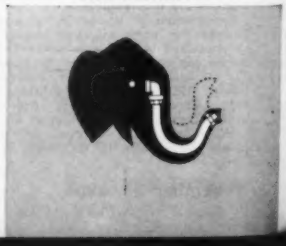


MOVEMENT



XUM

Engineering News Roundup

Machines Will Read and Sort Bank Checks, Business Papers

DAYTON, OHIO; STAMFORD, CONN.—Automatic "sorter-readers" of checks and other original forms for use in connection with electronic data-processing machines for banks and offices will be developed jointly under a recent agreement by National Cash Register Co. and Pitney-Bowes Inc. Separately, the companies also plan expansions of their present product lines.

The sorter-readers, operating at speeds up to 750 items per minute, will electronically "read" data printed or coded on checks and other original business forms. Then they will feed the information into accounting machines and sort the original material as may be desired. Punched cards, or tape, prepared from original forms, are the only generally used mechanical means of accomplishing these purposes at present.

Ordnance Men Demonstrate New U. S. Weapons

Balanced Defense Said to Need Varied Sizes and Capabilities

ABERDEEN PROVING GROUND, MD.—Nine new weapons, never before shown to the general public, were demonstrated at the recent 38th annual meeting of the American Ordnance Association. The new equipment represented the full range of weapon types from individual infantry weapons and aircraft armament to complex rockets, both guided and aimed.

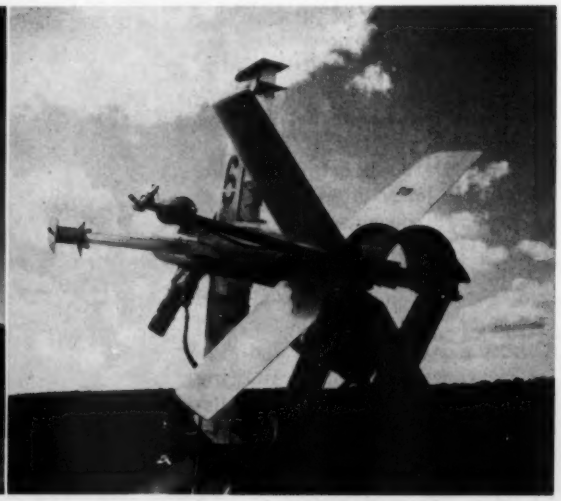
Commenting on the assortment of weapons shown, Wilbur M. Brucker, Secretary of the Army, said, "It would be a grievous error for anyone to think that because it now has atomic weapons and guided missiles, the Army can discard all of its conventional weapons and rely on atomic weapons alone."

In the small weapons class, Ordnance men demonstrated a lightweight, general-purpose machine gun developed to replace the several 30-caliber types currently used by ground troops. The gun weighs 23 lb while the guns it replaces weigh 32 to 42 lb. Its cyclic rate is 600 rounds per minute, the same as present weapons. The barrel and gas system can be replaced in a matter of seconds.

Show-stopper in the small weapons class was the Vulcan 20-mm automatic cannon for aircraft. Using the principle of the Gatling gun patented in 1862, the Vulcan has six barrels mounted in a cluster. The cluster rotates when the gun is operated from an external power source. Barrels fire individually when they reach one position in the cluster cycle. Other events in the operating cycle occur at the five other barrel positions.

In the field artillery class, a new 175-mm gun, T45, is claimed superior to all existing guns in the

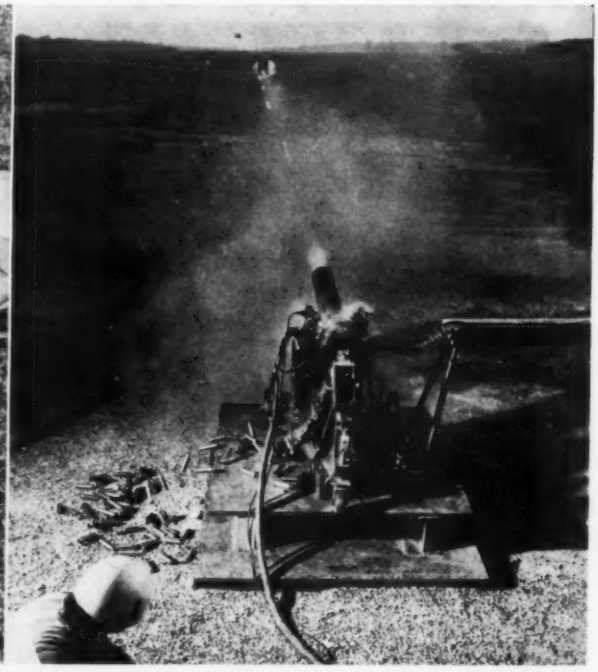
Honest John, a 762-mm rocket designated M31, is a surface-to-surface, fin-stabilized weapon. Aimed rather than guided, Honest John is carried and fired on its own vehicle.



Dart Guided Missile is intended for use by ground forces against surface targets. Dart is about 5 ft long, driven by a smokeless propellant. Maneuverability makes it relatively safe from small-arms fire.

←Circle 506 on page 19

Lightweight Machine Gun, 7.62 mm, designated T161E3, has been developed for Army Ordnance Corps as potential successor to current standard 30-caliber machine guns for infantry use. The new gun weighs 32 lb, has a cyclic rate of 600 rounds per minute, can be fired from shoulder, hip, bipod or tripod.



Aircraft Machine Cannon, 20 mm, named Vulcan has cluster of 6 barrels which rotates during operation. Ammunition from a single belt is loaded in the barrels at one position and fired at another. Electric or hydraulic external power, rather than the ammunition itself, operate the gun. Total weight is about 300 lb.

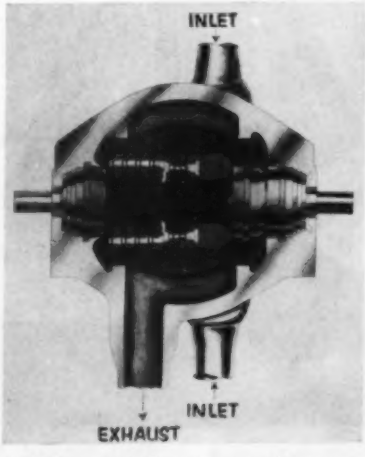
same size range. It incorporates many features of the 280-mm atomic cannon. Using hydraulic-electric power, it occupies a firing position without the need of digging recoil and spade pits, and it fires at any position in a complete circle.

New missiles demonstrated included Honest John and the Dart. Honest John is a 762-mm surface-to-surface aimed rocket. It is transported and fired from its launcher. Dart is a smaller rocket, about 5 ft long, intended for use by ground troops mainly against tanks.

Largest of the missiles shown was the Redstone Ballistic Missile. Equipment and technique for field launching were demonstrated. Vehicles that represented a firing platoon of a Field Artillery Missile Battalion for the Redstone included a 25-ton crane and trailer, an auxiliary trailer for the launcher, fire control and test truck, two trailers for missile parts, three fuel trucks and an air compressor truck.

Most Powerful Steam Turbine Will Have Stainless Casing

PITTSBURGH, PA. — Plans for the world's most advanced steam turbine for electric power generation currently involve tests in which stainless steel is subjected to steam above the critical pressure and at temperatures almost as hot as pure molten aluminum. In the Westinghouse Research Laboratories, steam at 16,000 psi and 1200 F is being used to test the strength of stainless steel proposed for the casing of the new turbine.



Stainless steel for steam turbine casing withstands operating conditions of 16,000 psi and 1200 F.

The turbine and the electric generator it drives will constitute a turbo-generator unit rated at 325,000 kw—enough for the residential needs of a city of 1,000,000 people. The unit is being construc-

Front Cover

Flange joints frequently must be designed to resist bending as well as tensile and compressive loads. Bending loads can produce unusual deflections in the basket, to the point where loss of sealing occurs. The Data Sheet by B. B. Clements beginning on Page 119 discusses some of these effects and tells how to analyze bolted flange joints.

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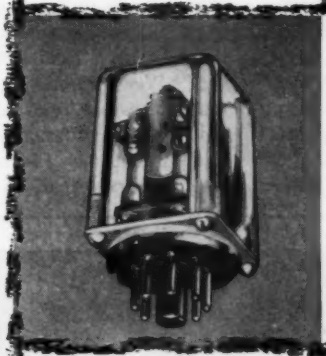
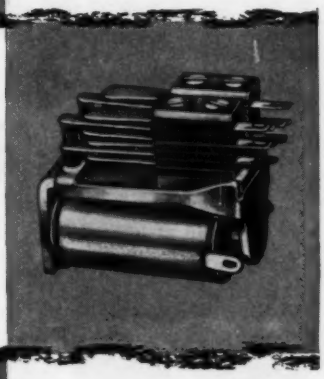
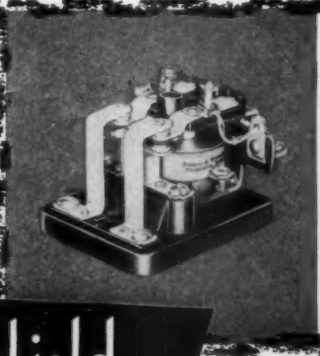
(In both voltage and current actuated models.) (Sensitivity 75 M.W. for current actuated models.) Medium cost, light weight, hermetically sealed relay for light contact load application. Size: ¾" diameter 1 13/16" high (above standard 7-pin miniature tube socket).



KRP SERIES
Versatile, multi-contact arrangements. Enclosed in polystyrene dust cover. Contacts: rated 5 amperes. Dimensions: 1 13/32" x 1 13/32" x 2" high (above standard 8 or 11 pin octal style socket.) Weight: 3 oz.

MH SERIES
Extremely fast acting and long life. DC models available up to 10 g—500 cps vibration and 30 g shock. Available 4 form C contacts and variety of mtg. arrangements. Maximum size 1 5/8" x 25/32" x 1 1/16" high.





PR SERIES
Heavy duty relay with screw terminal for all industrial control applications. All AC models can carry UL label. Size: 2½" wide x 3¾" long x 2 7/16". Mounting: Two holes 3/16" dia. on 1 7/8" centers. Contacts: Capacity, 15 amperes single break and 20 amps double break.

KA SERIES
A small, low cost, highly efficient general purpose relay with 5 amp. silver contacts. Can be insulated to meet UL requirements. Size: 1¼" x 1 27/32" x 1 3/16". Mounting: One No. 6/32 stud and locating tab.

XUM

ted by Westinghouse for the Philadelphia Electric Co.

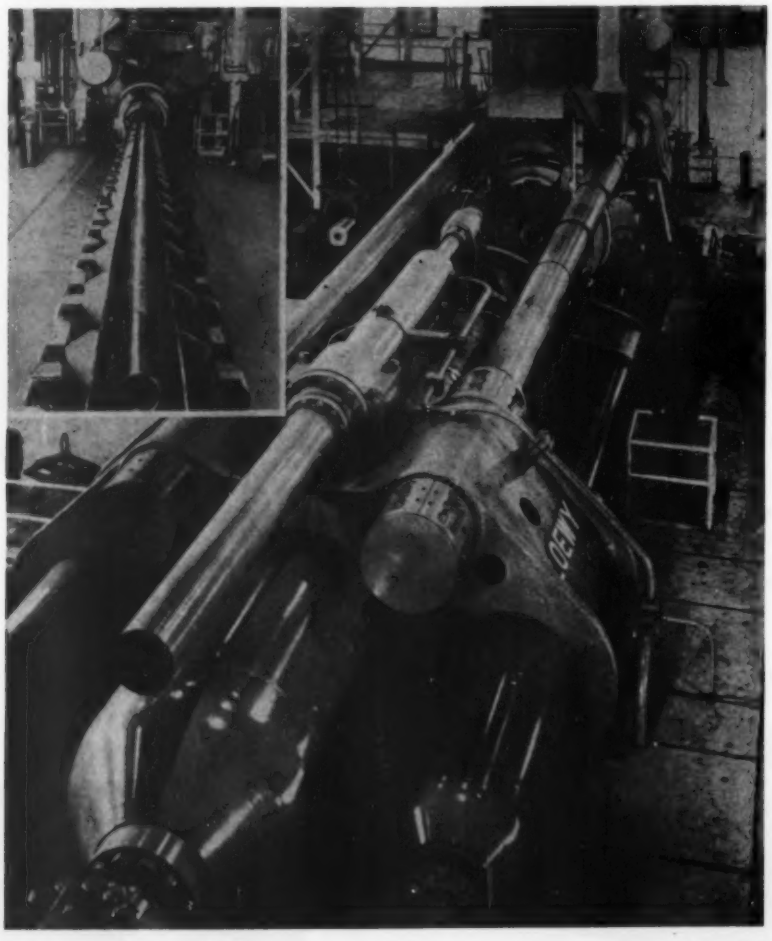
The turbine portion of the unit will have the highest operating temperature and pressure, as well as the highest efficiency, of any existing or proposed steam turbine.

It will operate with a steam pressure of 5000 psi—about twice the pressure of any present-day turbine for electric utility service. The temperature will be 1200 F. The turbine will be one of the first commercial units to operate with steam above the "critical" pressure.

When heated at atmospheric pressure, water ordinarily changes from a liquid to a gas. Above the critical pressure of 3206 psi, however, water does not change into a gas, no matter how hot it is heated. Under these conditions, the water behaves as a supercritical fluid, neither liquid nor gas.

This supercritical fluid that will be used in the new turbine is also used in a testing machine to evaluate the turbine materials.

The tests indicate that the casing will easily withstand the higher temperatures and pressures. In fact, Westinghouse engineers state, there is no scientific reason why these operating conditions should not be pushed higher in turbogenerators of the future.



STEEL AND TITANIUM EXTRUSIONS are the products of this 12,000-ton press now in full operation at the Curtiss-Wright Metals Processing Div. in Buffalo. Built by the Loewy-Hydropress Div. of Baldwin-Lima-Hamilton, the 126 ft long machine is the only press in the U. S. Air Force heavy press program for the extrusion of steel and titanium aircraft components. A tube 50 ft long and 6 in. in diameter can be extruded in 9 seconds, and 1000 ft of ½-in. spring steel rod can be extruded in 3 seconds.

Topics

New radar system indicates the position of the vessel on which it is carried, as well as the location of all other objects in the area. This system eliminates the necessity for a navigator to plot the movement of his ship and others in the vicinity. Range is 45 miles.

• • •

Spare tire in the glove compartment is advocated by Gates Rubber Co., developer of a compact spare tire kit. The kit consists of a tool to remove a tire casing from a wheel; a carbon dioxide cartridge for inflating the spare; and the tire itself, a nylon-cord, ¼-in. tread model that can be folded to fit into a glove compartment. That's fine—but where will we put our gloves?

• • •

Speed of 4000 mph at 38-mile altitude is to be attained by the X-15 rocket-powered research plane, now under development. The plane is expected to be ready for flight in about two years.

• • •

In the bag in seconds' time go groceries that are packed for their trip home by a new automatic counter setup. A conveyor belt brings the items to the cashier, who places them in a bin. Bags are then automatically opened and loaded. Despite its speed, the bagger is said to be gentle with fragile items such as eggs and light bulbs.

• • •

Now hear this: a mobile communications type speaker with built-in transistor amplifier has been introduced by Motorola. This Power-Voice speaker provides up to ten times the audio output of standard positive speakers.

• • •

Antimissile missile is under development by the Army and should be completed within five years.

• • •

Nuclear-powered surface craft are planned by the Navy, and an 11,000-ton vessel is due to make its appearance next year. Construction of a nuclear-powered aircraft carrier is expected by 1958. A spokesman for the Argonne National Laboratory recently said that all naval vessels and some types of commercial ships built after about 1960 probably will be nuclear powered.

Circle 508 on page 19→

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XUM

Rounding Up the 1957 Automobiles

HIGHER horsepower and lower silhouettes characterize the 1957 automobiles now being introduced. Evolution in body design is marked by the growth of rear fins in many of the cars. Restyling has reduced the height of some models by several inches.

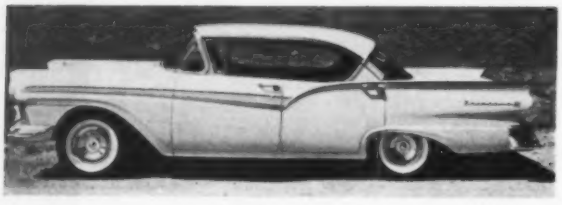
Other innovations include dual headlights; new suspension systems; and wider, more rigid frames. Fourteen-inch wheels with wider-tread, lower-pressure tires are used extensively.

New engine designs offer such developments as fuel injection, two or four-barrel carburetors, dry-type air filters and larger intake valves to improve performance. Compression ratios are higher.

Optional equipment being introduced with the 1957 models includes combined heating and air conditioning systems,transistor radios, and numerous power accessories, such as six-way seats.

FORD

The 1957 Fords are available in 19 body styles with three different body sizes on two chassis lengths. The largest body is more than 9 in. longer and 4 in. lower than 1956 models. The frame is almost as



wide as the car's body, permitting lowering of the floor inside the frame rails. A tapered driveshaft enters the rear axle almost an inch lower than in the 1956 models. Wheels are 14 in. diam and have low-pressure tires with increased tread surface. Fuel tank capacity is 20 gal.

Three V-8 engines and one six-cylinder engine are available. The 245-hp Thunderbird Special V-8 is optional on any model for the first time. V-8 engines are equipped with automatic chokes. New in this year's engine are a dry-type air filter said to last for 20,000 miles of driving; low-silhouette carburetors; larger intake manifold; centrifugal-vacuum distributor; and rotor oil pump. All but the 245-hp engine have a new exhaust system with pipes from the two manifolds leading to a single muffler.

Engine Specifications

	I-Six	Y-8
Type	OHV, In-Line	OHV, Vee
No. cyls.	6	8
Bore & stroke (in.)	3.62 x 3.60	3.62 x 3.60
Displ. (cu in.)	223	272
Comp. ratio	8.6 to 1	8.6 to 1
Bhp, max		
Fordomatic	144 @ 4200	190 @ 4500
Overdrive or conv. trans.	144 @ 4200	190 @ 4500

	Thunderbird V-8	Thunderbird Special V-8
Type	OHV, Vee	OHV, Vee
No. cyls.	8	8
Bore & stroke (in.)	3.75 x 3.30	3.80 x 3.44
Displ. (cu in.)	292	312
Comp. ratio	9.1 to 1	9.7 to 1
Bhp, max		
Fordomatic	212 @ 4500	245 @ 4500
Overdrive or conv. trans.	206 @ 4500	245 @ 4500

Size

	Fairlane & Fairlane 500 Sedans & Victorias	Custom & Custom 300 Sedans	Station Wagons
Wheelbase (in.)	118	116	116
Length (in.)	207.7	201.6	203.5
Width (in.)	77.0	77.0	77.0
Height, loaded (in.)	56.2	57.1	58.6

RAMBLER

A V-8 engine, rated at 190 hp, will be available for the first time on the 1957 Rambler. It has a two-barrel carburetor and dual mufflers and exhaust pipes. Downward-pointing tailpipes are concealed by

the bumpers. A cellulose-fiber air cleaner is standard on the V-8 engine.

Horsepower rating of the six-cylinder engine has been raised to 125 or, with an optional dual-throat carburetor, to 135. Three types of transmission are available on both the six and eight-cylinder models.

Thirteen models are included in the Rambler line. All are on a 108-in. wheelbase. The front end was redesigned to incorporate larger parking - turning lights and the addition of a horizontal chrome bar in

Effective sealing with confined resilient gaskets

In order to seal a metal-to-metal joint effectively, a gasket must meet at least two basic requirements. It must completely fill the recessed gasket channel to provide maximum contact with the mating flange . . . and it must be able to be compressed sufficiently to prevent leakage of the sealed medium.

cork-and-rubber gaskets

Both of these needs can be met with gaskets cut from truly compressible materials such as cork-and-rubber composition. (If non-compressible rubber gaskets are used, either relief must be provided for sideflow, or the gasket must be cut so that its volume does not exceed that of the cavity. Also, the initial shape of a rubber gasket must permit 20 per cent deflection when the joint is closed.)

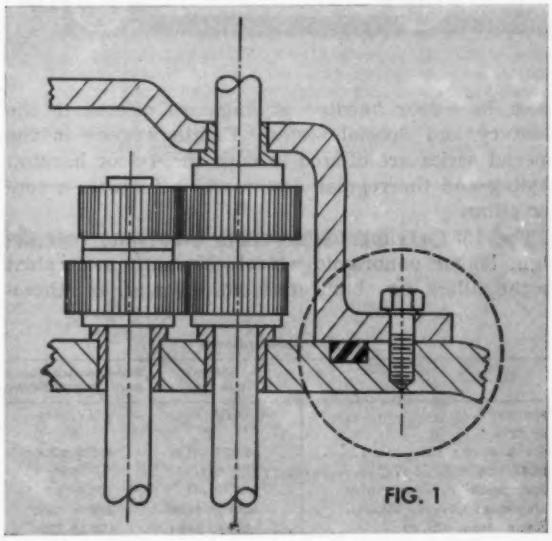


FIG. 1

filling the channel

To fill a channel completely, cork-and-rubber gaskets are cut to full channel width and, depending on their degree of compressibility, from 1.25 to 1.5 times channel depth. Because these cork-and-rubber gaskets actually decrease in volume under load, they do not require relief for sideflow or excessively close gasket and metal tolerances.

correct compression

Correct gasket compression is also assured with the right cork-and-rubber composition. Each cork-and-rubber material combines precisely controlled amounts of truly compressible cork and non-compressible synthetic rubber. As a result, a cork-and-rubber gasket can provide a pre-determined degree of compressibility to handle the required flange load.

typical applications

Typical of the metal-to-metal sealing jobs done by cork-and-rubber gaskets is the instrument housing flange shown in Figure 1. Completely confined, the cork-and-rubber gasket prevents leakage of the lubricating oil and permits perfect alignment of the gears.

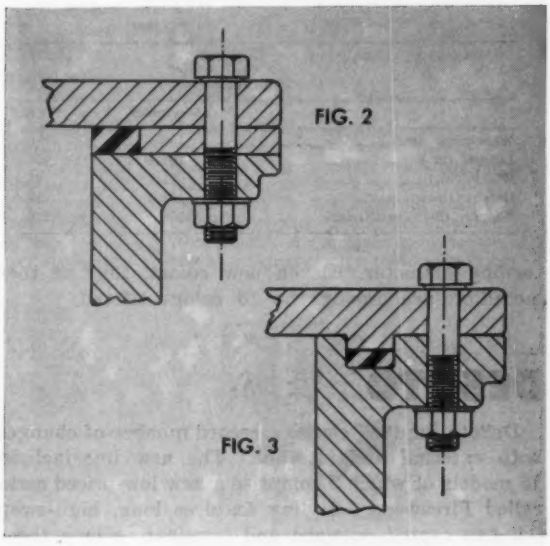


FIG. 2

FIG. 3

In Figure 2, flat flanges were adapted to metal-to-metal sealing by the insertion of an annular shim. Here, the cork-and-rubber gasket compresses to form a tight seal without tending to flow out of position.

The high pressure metal-to-metal flange shown in Figure 3 utilizes a stop to prevent blowouts. By completely filling the confined channel, cork-and-rubber maintains a tight seal.

SEND FOR 24-PAGE GASKET DESIGN MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy to Armstrong Cork Company, Industrial Division, 7111 Dean Street, Lancaster, Pa. For information on all Armstrong Gasket Materials, see Sweet's product design file.

Armstrong

GASKET MATERIALS

. . . used wherever performance counts

Circle 509 on page 19

XUM

the grille. Wheel rims are wider, and 6.70 by 15 tires are standard on the V-8's, optional on the sixes. A new steering gearbox makes possible a 37½-ft turning diameter. Eleven new colors, four of them metallics, are among the 15 colors offered.

Engine Specifications

	6-cylinder	V-8
Type	In-Line	90-deg Vee
No. cyls.	6	8
Bore & stroke (in.)	3.125 x 4.25	3.50 x 3.25
Displ. (cu in.)	195.6	250
Comp. ratio	8.25 to 1	8.0 to 1
Bhp, max	125 @ 4200 135 @ 4500*	190 @ 4900
Torque, max (lb-ft)	175 @ 1600 180 @ 1800*	240 @ 2500

*With optional dual-throat carburetor

Size and Weight

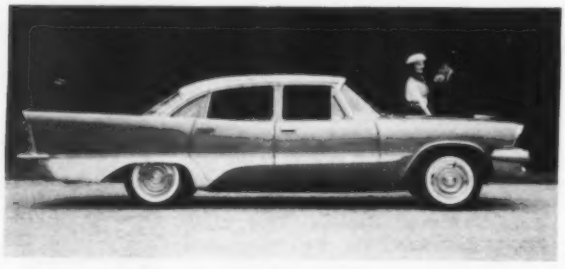
	6-cylinder	V-8
Wheelbase (in.)	108	108
Length (in.)	191.1	191.1
Width (in.)	71.3	71.3
Height (in.)	58.0	58.4
Weight (lb) (unofficial)	2900	3175

DESOTO

DeSoto for 1957 claims a record number of changes, both external and internal. The new line includes 15 models of which 5 comprise a new low-priced series called Firesweep. Styling features long, high-swept tail fins canted outward and terminating in a three-unit tail lamp cluster. Firedome and Fireflite models can be equipped with dual headlights in states where legal, and all three series have 14-in. tires.

A new Torqueflite 3-speed automatic transmission is standard on Fireflite models, optional on the other two series. The console of 5 gear change push buttons is at the left of the instrument group. Powerflite 2-speed automatic transmission is optional on Firesweep models. Power brakes are available except on models that have manual transmission. All models have new torsion-bar front suspension and longer leaf springs in the rear.

Explorer-class station wagons in the Fireflite and Firesweep series have new Goodyear nylon tires that feature independent air chambers. If the new tire is punctured, it retains enough air to be driven up to 100 mi.



Engine Specifications

	Firesweep	Firedome	Fireflite
Type	OHV, Vee	OHV, Vee	OHV, Vee
No. cyls.	8	8	8
Bore & stroke (in.)	3.69 x 3.80	3.78 x 3.80	3.78 x 3.80
Displ. (cu in.)	325	341	341
Comp. ratio	8.5 to 1	9.25 to 1	9.25 to 1
Bhp, max	245 @ 4400*	270 @ 4600	295 @ 4600
Torque, max (lb-ft)	320 @ 4400*	350 @ 2400	375 @ 2800

*For engines equipped with standard 2-barrel carburetor.

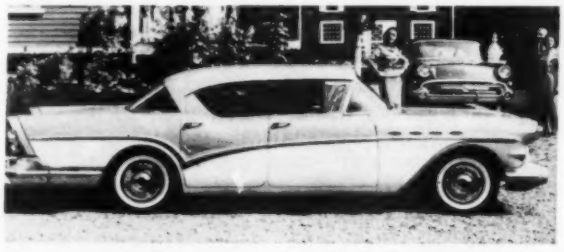
Size and Weight

	Firesweep	Firedome	Fireflite
Wheelbase (in.)	122	126	126
Length (in.)	215.8*	218.0*	218.0*
Width (in.)	78.2	78.2	78.2
Height (in.)	56.7	57.0	57.0
Weight (lb)	3675	4005	4025

*Except station wagons.

BUICK

Buick's 1957 line comes in 20 body styles with two and four-door hardtops and a convertible in each series. Two and four-door sedans are offered in the Special series only. Three estate wagons, two of them in 4-door hardtop styling, are offered in the Century and Special series. Estate wagons in the Special series are offered in both the 4-door hardtop styling and the regular design which features a center pillar.



The 1957 styling features new front and rear design, bigger panoramic windshields with more slant to the pillars, new bumpers front and rear, and three-piece back windows on the Special, Century and Roadmaster. All of the new cars have been reduced in height. Some models are more than 3 in. lower than

Engine Specifications

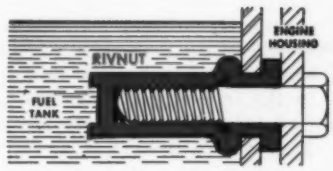
	Special Series	Roadmaster, Super and Century Series
Type	OHV, Vee	OHV, Vee
No. cyls.	8	8
Bore & stroke (in.)	4.125 x 3.4	4.125 x 3.4
Displ. (cu in.)	364	364
Comp. ratio	9.5 to 1	10.0 to 1
Bhp, max	250 @ 4400	300 @ 4600
Torque, max (lb-ft)	380 @ 2400	400 @ 3200

Size

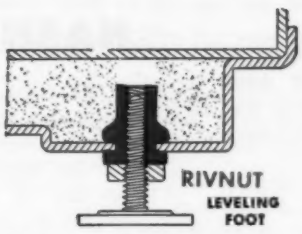
	Special	Century	Super	Roadmaster
Wheelbase (in.)	122.0	122.0	127.5	127.5
Length (in.)	208.4	208.4	215.3	215.3
Width (in.)	74.8	74.8	77.6	77.6
Height (in.)	58.4	58.7	59.4	59.3

B.F. Goodrich Rivnut

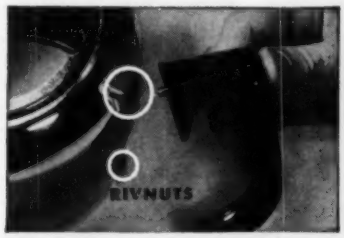
solves practically any fastening problem



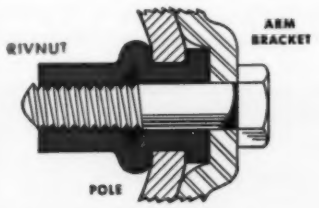
MAKES NUT PLATE, SEAL. Quickly installed in gas tank wall, Rivnut makes firm, accurate nut plate that can't be loosened by shock or vibration. At least six threads are clean for bolt attachment to engine housing. Straps, rivets, braces, nuts are eliminated. Rivnut's special closed end makes 100% gasoline-tight seal.



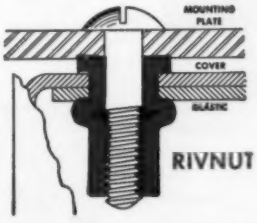
NEW WAY TO FASTEN LEVELING FEET. Appliance manufacturers install Rivnut in metal too thin to tap or weld *after* enameling. Bulge in Rivnut shank (second head) firmly grips the material. At least six threads remain clean to take the leveling foot screw—more than enough to handle the weight of heavy appliances.



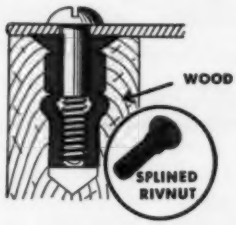
SPEEDS HANDLE ASSEMBLY. B. F. Goodrich Rivnut saves time fastening handle to small appliance. It provides a strong nut plate in *seconds*. Replaces slower fastening methods like nuts and bolts, welding, clinching, tapping. Rivnuts can be installed from one side and the open end types can take an attachment screw from either side.



CUTS ASSEMBLY COSTS 50%. In a street light application, it took two men to fasten the arm bracket to the pole. Then the manufacturer redesigned the unit to use Rivnuts. Now one man can do the job in the same time. Tests show the pole or arm bracket will fail before the Rivnuts.



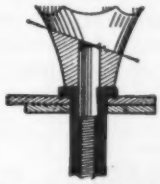
DOES TWO FASTENING JOBS. Rivnuts simplify transformer assembly from start to finish. Starting with unassembled parts, worker fastens sheet of plastic to metal cover with Rivnuts. With cover secured to frame, the Rivnuts then serve as mounting plate.



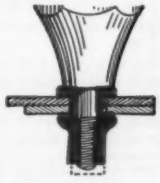
NEW WAY TO FASTEN TO WOOD. Special splined Rivnut for solid fastening in wood eliminates wood screws, provides six metal threads for attachment bolt. Bulge formed in shank holds Rivnut fast. Splined shaft keeps it from turning. Used for bus seats, metal backs in TV sets, etc.

How Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy by writing to: The B. F. Goodrich Company, MD-116, Akron, Ohio.

B.F. Goodrich

RIVNUTS

The only one-piece blind rivet with threads

Circle 510 on page 19

XUM

last year, without sacrifice in ground clearance.

Two new features have been incorporated in the front end suspension system for 1957. For the first time, a ball-joint suspension is used to improve the stability of the car on corners and curves, and a new anti-dive device reduces front end dive on fast stops. Coil springs, both front and rear, are continued on all models.

Optional on all models is a safety minder which buzzes constantly when a predetermined speed is reached. The safety minder can be set at any speed desired by turning a knob on the instrument panel.

DODGE

The new Dodge has ball-joint, torsion-bar front suspension to counteract vibration, noise and shock. Rear leaf springs are mounted outside the frame

to increase stability and reduce sway on turns. The new suspension system, a thinner roof, a paper-element type air cleaner that is located against the side of the engine, and the floor recessed in the frame all contribute to reduction of the Dodge's overall height.

Engines have larger displacement and higher compression ratio. New Torque-Flite automatic transmission, available on all V-8 models, has pushbuttons for first and second gear, as well as drive, neutral and reverse. Power-Flite transmission is available on six and eight-cylinder Coronet models only.

Engine Specifications

	Getaway 6	Red Ram V-8	D-500
Type	In-Line	OHV, Vee	OHV, Vee
No. cyls.	6	8	8
Bore & stroke (in.)	3.25 x 4.63	3.69 x 3.80	3.69 x 3.80
Displ. (cu in.)	230	325	325
Comp. ratio	8.0 to 1	8.5 to 1	9.25 to 1
Bhp, max	138 @ 4000	245 @ 4400*	285 @ 4800
		260 @ 4400†	310 @ 4800‡
Torque, max (lb-ft)	208 @ 1600	320 @ 2400*	345 @ 2800
		335 @ 2800†	350 @ 3200‡

*Red Ram. †Super Red Ram. ‡Optional with two 4-barrel carburetors.

Size

	Four-Door Sedan	Two-Door Lancer Hardtop
Wheelbase (in.)	122.0	122.0
Length (in.)	212.2	212.2
Width (in.)	77.9	77.9
Height, loaded (in.) (Coronet)	58.6	54.1

The Dodge rides on 14-in., double-tread tubeless tires. New floating-shoe Total-Contact brakes are claimed to require less pedal effort and to last longer than previous types.

Optional equipment includes a rear-window defroster, a transistor radio and a single-control air-conditioning and heating system that is contained entirely in the engine compartment.

NASH

The Nash Ambassador features a four-headlight system on its 1957 model. The 5¾-in. diam lamps are mounted vertically in the fenders. All four are used for the high beam, and only the upper two are used for the low beam. The system is said to supply up to 100 ft more illumination than previous systems. Parking-turning lights, located at the top of the fenders, are visible from the side.

Styling changes make the new Ambassador 2 in. lower than the 1956 model. Wheels are 14 in. diam, and tires have a wider tread than previously. Front-tread measurement is over 59 in. Front fenders have full wheel cutouts, reducing turning diameter to 42 ft.

A new V-8 engine is available with Hydra-Matic, overdrive or synchromesh transmissions. A twin-exhaust system is standard, with downward-pointing

tailpipes concealed by the rear bumpers.

Equipment optional on both series includes power steering and power window lifts, transistor radio with speakers at both ends of the instrument panel, and a redesigned air-conditioning system. Solid colors and two or three-tone combinations are available.

Engine Specifications

Type	OHV, Vee
No. cyls.	8
Bore & stroke (in.)	4.00 x 3.25
Displ. (cu in.)	327
Comp. ratio	9.0 to 1
Bhp, max	255 @ 4700
Torque, max (lb-ft)	345 @ 2600

Size and Weight

Wheelbase (in.)	121.3
Length (in.)	209.3
Width (in.)	78.0
Height (in.)	60.4
Weight (lb) (unofficial)	3660*

*Super four-door sedan

MACHINE DESIGN's roundup of the 1957 model automobiles will be continued in the November 29 issue.

Machine Distributors Offer Aid for Engineer Shortage

COLORADO SPRINGS, COLO.—Current shortages of engineers can be partially offset if manufacturers will place greater reliance on existing nationwide capital goods distributing organizations, thereby permitting qualified engineers to transfer from sales and service work to development and production assignments. This was the recent statement of Henry R. Hanson, president of the American Machine Tool Distributors' Association.

"The job of developing and producing capital goods," Mr. Hanson said, "has placed a particularly severe burden upon the engineering departments of manufacturers and builders selling to manufacturing industries. They urgently need every engineer they can employ in order to fully staff their constantly expanding research and production programs. Hence more capital equipment producers are making fuller use of the sales engineering assistance available to them through industrial equipment distributors. They have found that outside distributors can help them free more engineers for important development and production assignments in their own plants."

3-D TV Views, Monitors Remote Handling Apparatus

CHICAGO, ILL.—An advanced type electromechanical manipulator for use with 3-D television for the fully remote handling of radioactive and other dangerous materials has been developed by Borg-Warner Corp.

The manipulator consists of a master or control unit which is connected by an electric cable to a remote "slave" unit that actually handles the dangerous material.

The two units may be a few feet apart, a city block, or a mile, depending on the length of the connecting cable. For the longer distances, 3-D television equipment serves as the "eyes" of the operator. This type of TV gives depth dimension to an image.

(*Continued on Page 22*)

DRAFTING TRENDS

The trend is to Christmas Gifts he can use

Christmas gift lists are growing longer every year as new friends, relatives and young people are added. The problem of picking suitable gifts multiplies with every new name.

During recent years the trend has increasingly been to practical gifts. A useful present is appreciated all year long and is a constant reminder of the thoughtful person who gave it.

What engineer or draftsman wouldn't appreciate top-quality, *new* professional equipment for his office or home? And what could be of more value for the high school or college student than a set of quality drawing instruments and other basic tools for a promising career?

Here are four among the many popular Post Christmas gift suggestions. Each is built for a lifetime of service.

Adjusto Drawing Stand

Stand for drawing boards up to 24" x 36". Ideal for friends with home workshops. Made of well-seasoned, highly-finished, select hardwood. Folds flat for storage. Joints have easy-action, heavy gauge bolts with self-locking nuts. Board rest adjustable to eight different angles.

Dazor Lamp

Versatile lamp with soft, glareless, shadowless light. Change light location, direction and intensity with a touch of the finger. Patented *floating* Dazor arm stays put in each new position. Available in four bases: Desk, Pedestal, Universal (clamp or screw-on) and Bracket model.

Versalog Slide Rule

Reduces error hazards, requires fewer settings, gives unrivaled accuracy. R1 and R2 scales determine square roots with four times the accuracy of conventional A and B scales. Other innovations include: New end zone designations of log and log log scales, a fourth LL scale for increased range, color coded scales. Made of seasoned, laminated bamboo.

Custom-Master Drawing Instruments

Made of high nickel alloy content, tooled by master craftsmen at Post's Bavaria, Germany, factories. Weight and balance of each instrument meets highest precision standards. Quality Swedish steel used exclusively in pen parts. Combination Big Bows and a wide range of sets are available to meet specific requirements.

These are only a few of the many practical Post gifts you can give this Christmas. For more information, see your Post dealer or write today to the Reader Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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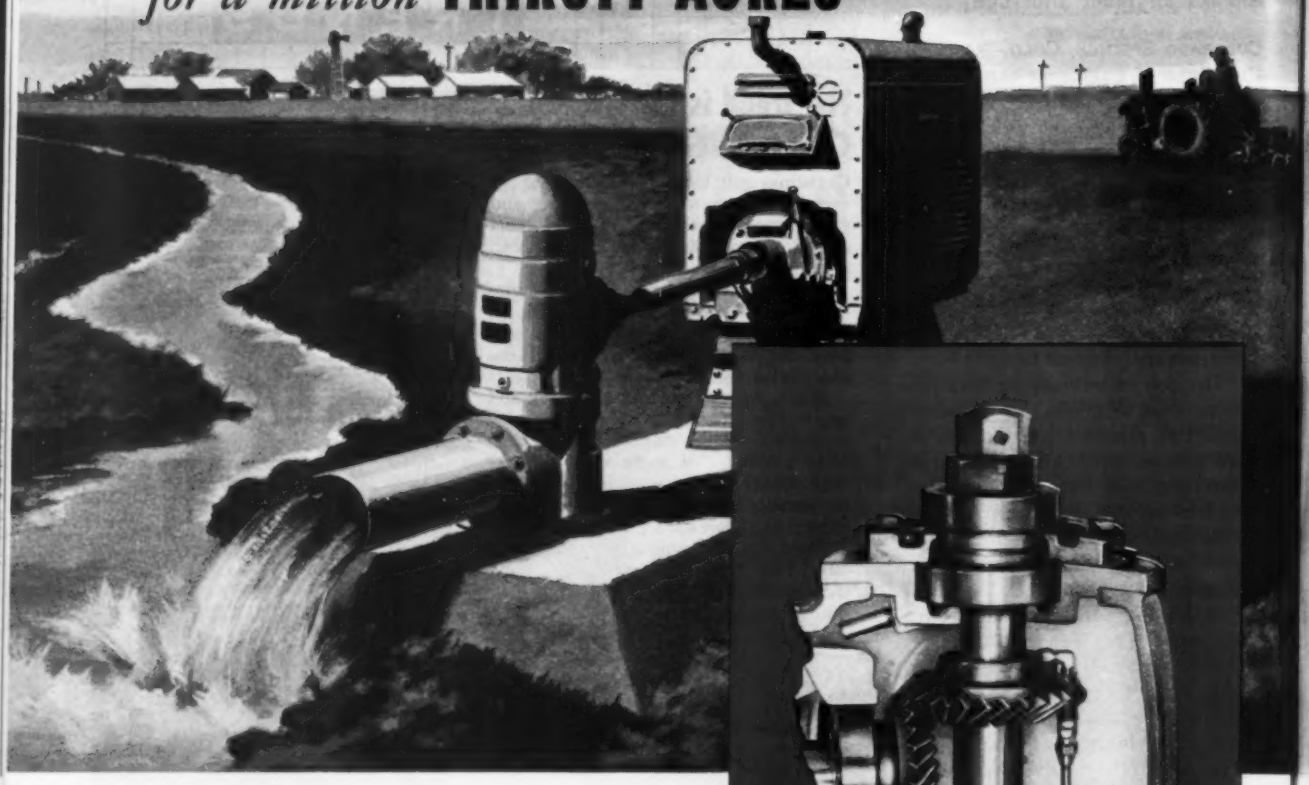
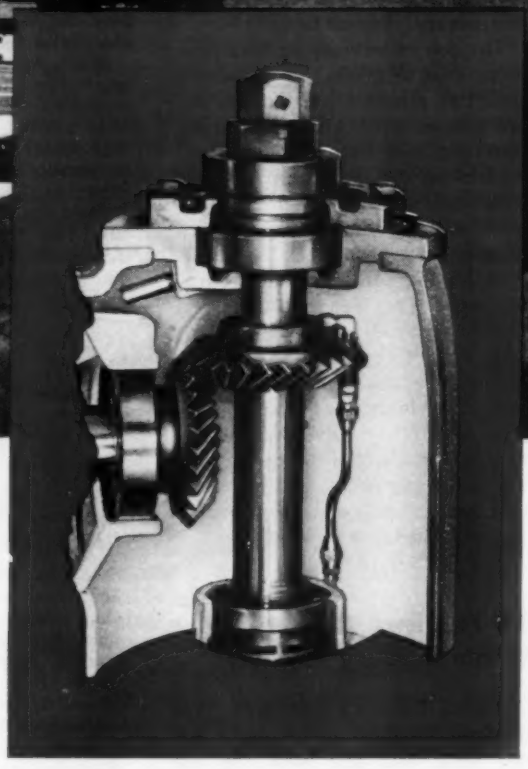
XUM

Turning POWER *into* WATER *for a million* THIRSTY ACRES





Here is work—hard work—needed work, for America's huskiest pumps. Here, where crops and livelihood depend upon them, you will find pumps engineered for the most reliable performance and endurance. One of the strongest points we can make about our gear drives is that they are specified as original equipment in the irrigation pumps of many manufacturers.

What is your power transmission problem? Why not write?

Cut-a-way shows gears of our manufacture in a typical heavy-duty irrigation pump.

DOUBLE DIAMOND GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914 — RICHMOND, INDIANA

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XUM

MACHINE DESIGN
READER SERVICE

Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature
BY ITEM NUMBERS

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406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
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410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
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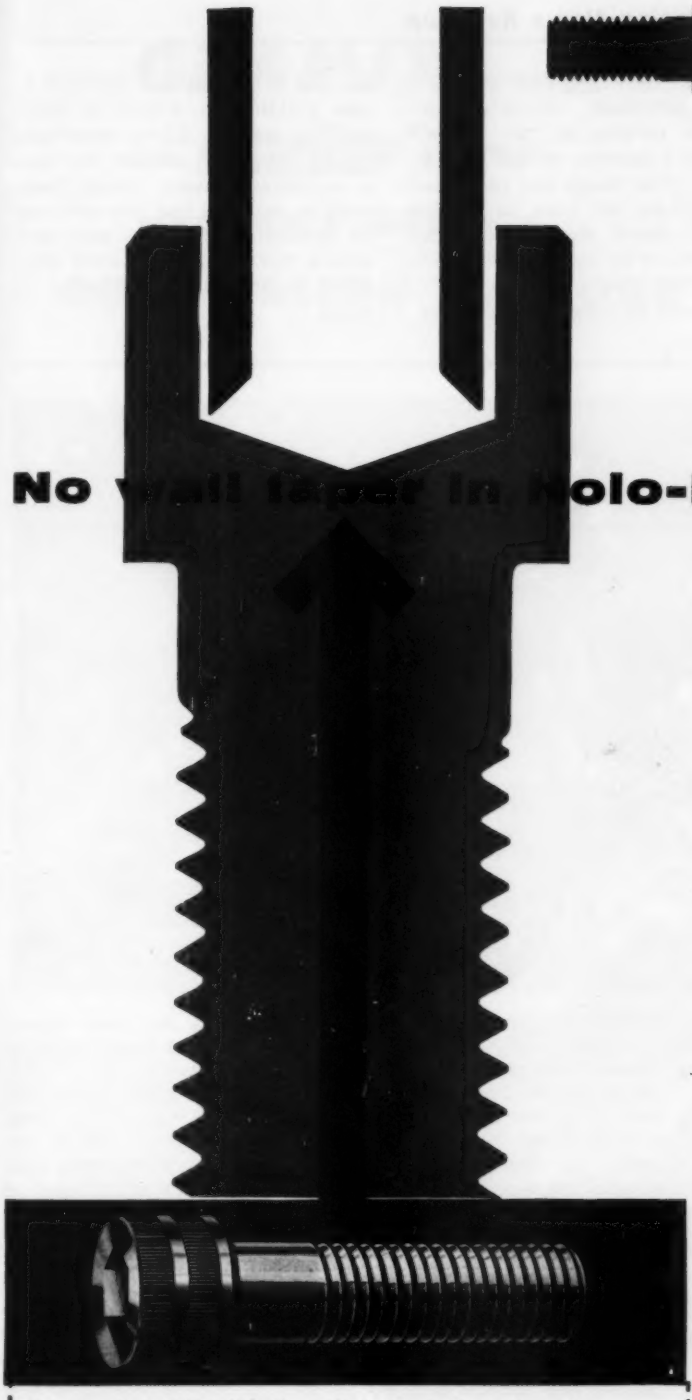
INSIDE INFO FROM HOLO-KROME



THE SECRET'S IN THE SOCKET!

Holo-Krome's forging method assures untapered sockets . . . lets the hex key bear evenly and firmly against the entire socket wall. The result: easier, faster assembly . . . longer key life . . . fewer damaged screws!

No wall taper in Holo-Krome sockets!

Compare These Other H-K Features!

COMPLETELY FORGED SOCKET HEAD . . . no drilling or broaching—metal fibers stay intact for stronger hex sockets.

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

SHARP HEX CORNERS . . . carefully formed socket corners resist internal reaming.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

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HOLO-KROME

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

Circle 513 on page 19

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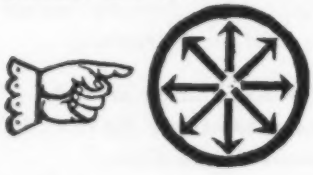
Nature abhors a vacuum

but a sphere resists pressure best of all



So when you're in a vacuum for ideas—or under pressure to produce—remember a ball!

A *perfect* ball (Universal makes them to tolerances of 10 millionths of an inch!) may be the perfect starting point for the answer to your problem.

You can start rolling on a ball of almost any type metal —and move in any direction!

Yes, Universal balls offer limitless possibilities to the designer and manufacturer. They'll move with any idea.

UNIVERSAL QUALITY CONTROL— FOR ALL AROUND PERFECTION

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

Circle 514 on page 19

Engineering News Roundup

(*Continued from Page* 15)

The television apparatus includes a camera at the "slave" unit and a monitor at the control station. The image can be transmitted either by wire, as in the case of closed circuit industrial television, or by conventional telecasting methods.

It would be possible, for example, for a manipulator operator in one building to actuate a slave unit to perform filing operations in an office in another building some distance away. Small items such as matches and pins also can be handled easily. The unit, estimated to cost approximately $24,000, requires 3 to 4 months to build.

SEEING THROUGH HEADPHONES, this soldier aims the Army Signal Corps' new portable radar designed for the use of front-line troops at night or in fog. Enemy movements are plotted with information from the radar detector. Developed by Sperry Gyroscope Co. and the Signal Corps Engineering Laboratory, the gear is housed in a case 14 in. high, 14 in. long, and weighs 25 lb. Usual radarscope is eliminated and signals received are audible sounds. The equipment distinguishes between moving personnel, track-type vehicles and wheeled vehicles. It provides elevation and range data accurate within 25 yds and can detect a man walking ½ mile away.

Sentences, Not Words, Stump Mechanical Translators

CHICAGO, ILL. — Sentence-for-sentence machine translation of language, now being studied at Massachusetts Institute of Technology, promises translation of higher quality than word-for-word translation, but it will require a great deal of effort to work out the linguistic details. This was reported recently by Victor H. Yngve, of M.I.T., in a symposium on communication theory conducted by the American Institute of Electrical Engineers.

Mr. Yngve summed up the state of the art of mechanical translation as follows:

Word-for-word translations can be made now on high-speed, general-purpose, digital computers.

Word-for-word translations could be made more economically by means of special-purpose machines built with existing technology.

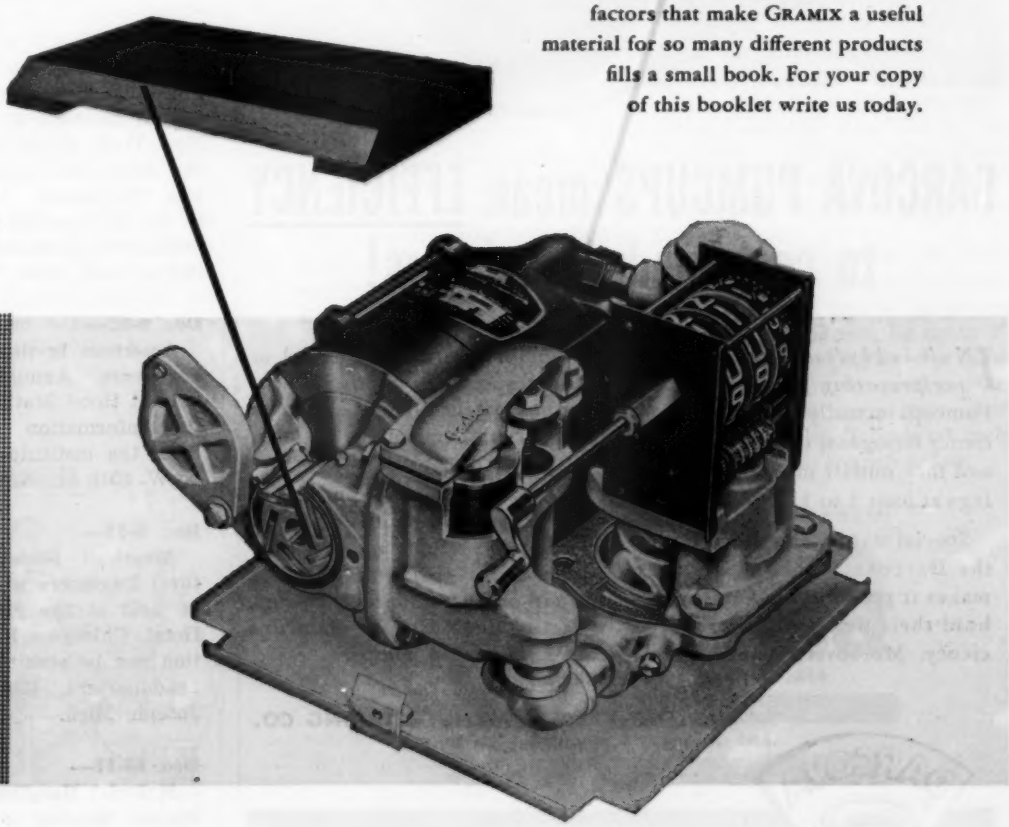
Word-for-word machine translations promise to be considerably cheaper than man-made translations.

Word-for-word translations are

GRAMIX® vanes in Gasboy® pump wear only .031" per ONE MILLION GALLONS

The Gasboy Super "200" gasoline pump is manufactured exclusively for farms, fleets, and industry by Wm. M. Wilson's Sons, Inc. in Lansdale, Pa. These pumps have proven to be accurate, efficient and dependable. But, what naturally interests us and will interest you, as a manufacturer or designer, are the GRAMIX vanes in these pumps. Tests reveal that the GRAMIX Grade 41 vanes still operated perfectly after pumping over 1,000,000 gallons of gasoline. During this endurance test, the vanes travelled around the inside of the housing a distance equal to 13,000 miles, or more than half way around the earth!

Not only these particular vanes, but hundreds of other GRAMIX parts are doing a successful job in appliances, aircraft, automobiles and an amazing variety of products. GRAMIX parts are die-pressed to close tolerances, and need no machining. They are strong, they are self-lubricating. The many factors that make GRAMIX a useful material for so many different products fills a small book. For your copy of this booklet write us today.



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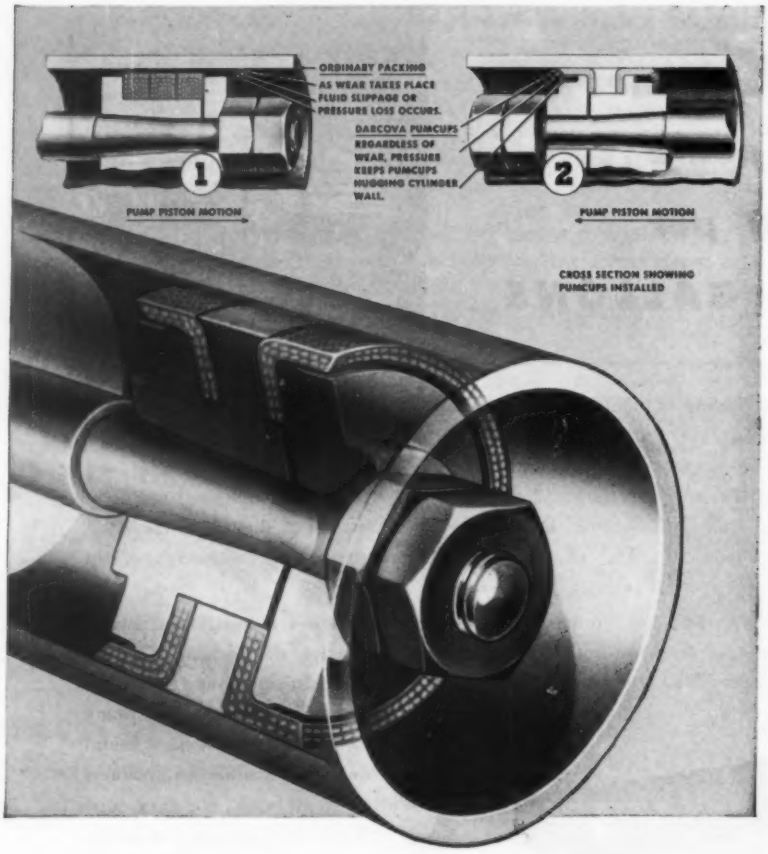


DARCOVA PUMCUPS mean EFFICIENCY to cost-minded engineers!

IN air and hydraulic cylinders and reciprocating pumps Darcova Pumcups actually retain full efficiency *throughout* their life span . . . and they outlast most other packings at least 3 to 1!

Special texture engineering plus the Darcova Pumcup principle makes it possible for Pumcups to hold their peak volumetric efficiency. Moreover, Pumcups permit equipment to be operated at reduced speeds, save power, prolong equipment life and eliminate the need for frequent replacement shutdowns.

For less maintenance and lower operating costs find out more about Darcova Pumcups. Write for Bulletin No. 4502 on Pumcups for air or hydraulic mechanisms, Bulletin No. 4401 on Pumcups for reciprocating pumps.

DARLING VALVE & MANUFACTURING CO.
Williamsport 30, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP
PUMCUPS

News Roundup

very crude, but may be useful when more accurate translations are not worth the additional cost.

If something better than a word-for-word translation is desired, our best hope is to take into consideration the sentence structure in designing a translation routine.

Providing translation routines on a sentence-for-sentence or structural basis requires a considerable amount of detailed liguistic work.

Meetings

AND EXPOSITIONS

Nov. 25-30—

American Society of Mechanical Engineers. Annual Meeting to be held at Hotel Statler, New York. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

Nov. 25-30—

22nd National Exposition of Power and Mechanical Engineering to be held at the Coliseum, New York, under the auspices of the American Society of Mechanical Engineers. Additional information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Dec. 9-12—

American Institute of Chemical Engineers. Annual Meeting to be held at Hotel Statler, Boston. Further information can be obtained from the institute's headquarters, 25 W. 45th St., New York 36, N.Y.

Dec. 9-12—

American Society of Agricultural Engineers winter meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from society headquarters, 420 Main St., St. Joseph, Mich.

Dec. 10-11—

Material Handling Institute Inc. Annual Meeting to be held at the Biltmore Hotel, New York. Further information can be obtained from institute headquarters, Suite 759, 1 Gateway Center, Pittsburgh 22, Pa.

Dec. 10-12—

1956 Eastern Joint Computer Conference to be held at the Hotel New Yorker. Sponsors are the Institute of Radio Engineers, American Institute of Electrical Engineers and the Association for Computing Machinery. Additional information is available from publicity chairman Albert J. Forman, Tele-Tech & Electronic Industries, 480 Lexington Ave., New York 17, N. Y.

Jan. 14-18—

Society of Automotive Engineers Inc. Annual Meeting to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

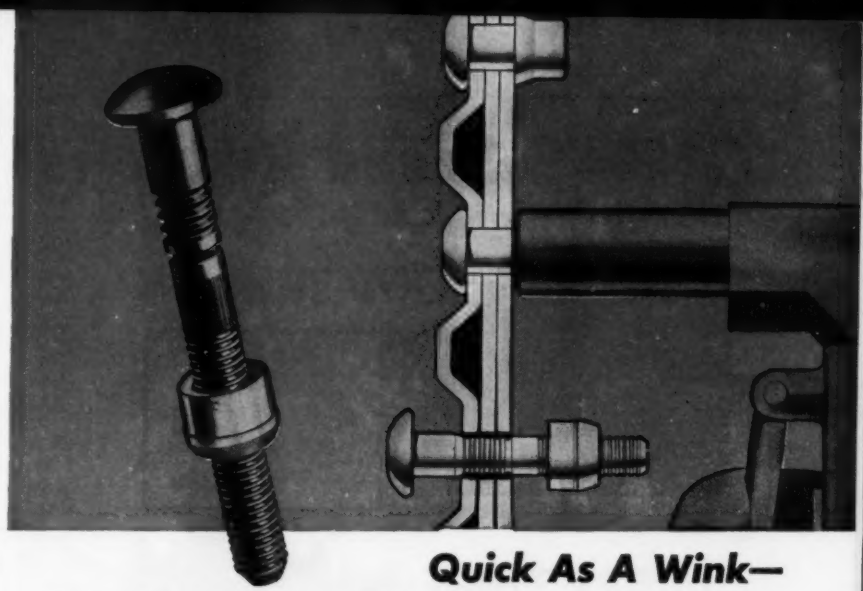
Jan. 16-18—

Society of Plastics Engineers Inc. Thirteenth Annual National Technical Conference to be held at the Hotel Sheraton-Jefferson, St. Louis. Further information can be obtained from society headquarters, 34 E. Putnam Ave., Greenwich, Conn.

Jan. 21-25—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

". . . then, just after you pass the foundry, you'll see a door here on the left . . ."



Quick As A Wink—
You Get Secure, Permanent Fastening With Townsend Lockbolts

In less than a second, with one squeeze of the trigger, a Townsend lockbolt pulls the work together with a high clinching action, is locked in place with uniform pressure. It is a quick method of producing tight, rigid, permanent fastenings that cannot loosen even under extreme vibration or shock conditions.

Townsend lockbolts combine the advantages of riveting and bolting—eliminate the disadvantages. Installation is fast—under certain conditions, one man will install 30 in only 60 seconds. Fewer workers will complete an assembly in less time than when riveting or bolting.

The clamping action, or clinch, of Townsend lockbolts is higher than rivets—is more uniform than bolts and nuts. The lockbolt fills the hole better than other fasteners, thus making possible a more rigid joint and also providing an effective liquid seal.

The Townsend lockbolt consists of two precision-made parts—a pin and a collar. Locking grooves are provided on the pin into which the collar is swaged by the pneumatic gun. The pulling section of the pin breaks in tension at a predetermined point when the setting action is completed.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16" and 3/8" diameters, in grip lengths ranging up to 2", in various head styles. For information on how to speed production, get tight, secure, permanent fastening with Townsend lockbolts, use the coupon below.

Licensed under Huck patent nos. RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049; 2,754,703.

THE FASTENING AUTHORITY

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NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

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TOWNSEND COMPANY
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New Brighton, Pa.

Please send without obligation "Lockbolt" Bulletin TL-101.

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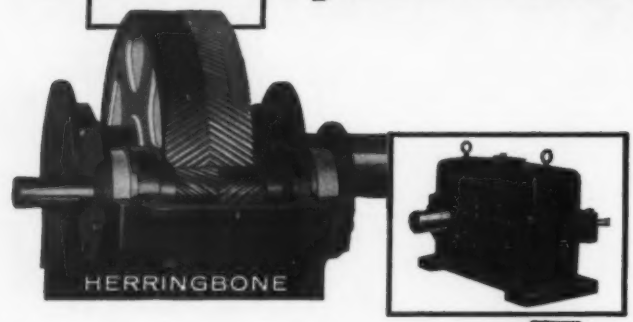
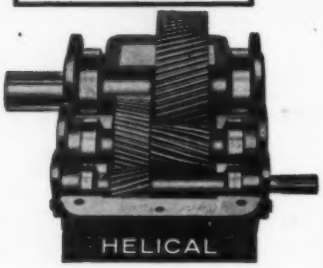
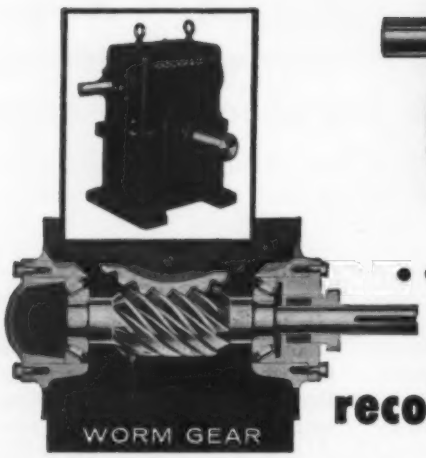
Circle 517 on page 19

3 H&S Speed Reducers







. . . assure unbiased recommendation

Each of these three general groups of H & S Speed Reducers has its particular mechanical advantages which make it more efficient for specific duties. There are many considerations, such as speed of driving and driven shafts, shape of housing and drive characteristics that must be considered for lasting reducer performance and economy.

With the complete H & S line of Speed Reducers to choose from, you can be sure of our unbiased recommendation and your selection of the right type reducer for each specific job.

H & S Reducers are available in single reduction units in ratios up to 100 to 1; in combination units up to 700 to 1; and in double reduction units up to 10,000 to 1.

Make H & S your source for *all* speed reducing requirements.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Send note on Company Letterhead for complete H & S Catalog

MEN

OF MACHINES

Spencer R. Griffith has been promoted to associate editor of MACHINE DESIGN. Mr. Griffith has been an assistant editor since September, 1955, when he came to MACHINE DESIGN from Hamilton Watch Co. There, he was a member of the watch design section, then advanced to engineering services supervisor in the research division. He was previously associated with Landis Machine Co. Mr. Griffith is a graduate of Lehigh University in mechanical engineering.

Spencer R. Griffith

Joy Mfg. Co., Pittsburgh, has appointed **Louis G. Helmick** to the newly created post of vice president and general manager of its Industrial Div. Mr. Helmick's responsibilities will include research and engineering of the division's products.

Formerly chief engineer, **B. L. Binford** has been elected vice president in charge of manufacturing of Magnetrol Inc., Chicago.

Zeke R. Smith has been appointed chief engineer and a member of the executive staff of Potter &

Brumfield Inc., Princeton, Ind. He will be in charge of all new product and applications engineering. Prior to his joining Potter & Brumfield three years ago, Mr. Smith was a member of the engineering staff of the Kansas City Div. of Bendix Aviation Corp.

Greer Hydraulics Inc., Jamaica, N. Y., has announced the appointment of **Baboo Ram Teree** as chief engineer. Mr. Teree was chief engineer of the Aircraft and Special Products divisions of the Weatherhead Co. from 1951 to 1956. He had previously served as director of engineering of the hydraulic division of New York Air Brake Co.; as project engineer in charge of aircraft equipment development

Baboo Ram Teree

and as director of the laboratories at the Weatherhead Co.; and, from 1931 to 1946, as hydraulic group engineer with the Curtiss-Wright Corp.

Donald M. Berges has been elected a vice president of Jack & Heintz Inc., Cleveland. His responsibilities will include activities relating to commercial motors and development of new product lines.

Edward C. Peterson has been elected vice president of the Rolling Mill Equipment Div. of Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa. Assistant to the vice president of engineering

NOW ...The Aerosol Lubricator

MACHINE TOOL DESIGNERS

Have been asking for

Norgren

MICRO-FOG® 33AG-4

COMPACT
This new unit measures 6-1/32" x 5-3/16" x 6-1/32".

COMPLETE
Includes an Air Line Filter, a relieving type Air Pressure Regulator, and a MICRO-FOG Lubricator with a large, ½ pint oil capacity.

ATTRACTIVE
Blends in with smooth flowing design lines . . adds to the appearance of a machine tool.

EASY TO INSTALL
Offers in-line pipe connections—optional locations of air inlet and filter drain. Has two outlets for filtered air —one for MICRO-FOG.

EASY TO MAINTAIN
No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

Model 33AG-4
Lubro-Control Unit
- Filter
- Regulator
- Lubricator

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BROCHURE 556.

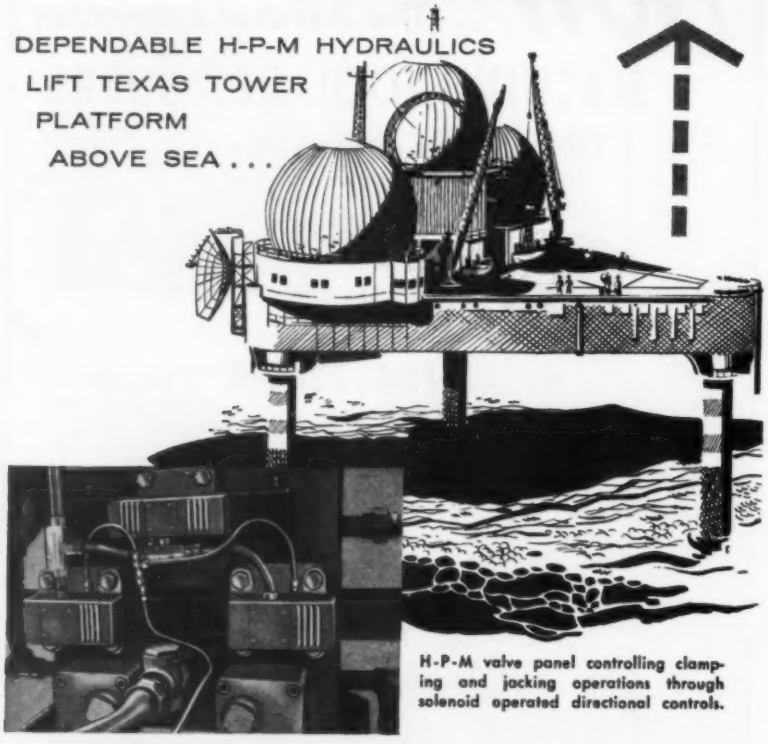
MICRO-FOG® by C. A. Norgren CO.

3442 SO. ELATI ST., ENGLEWOOD, COLORADO

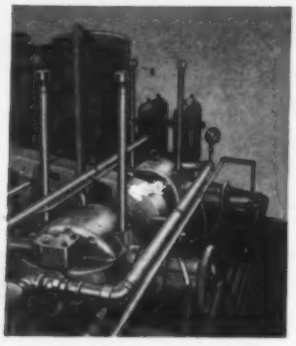
Circle 519 on page 19

ONE ISLAND . . . COMING UP!

DEPENDABLE H-P-M HYDRAULICS LIFT TEXAS TOWER PLATFORM ABOVE SEA . . .



H-P-M valve panel controlling clamping and jacking operations through solenoid operated directional controls.



H-P-M double pump, double circuit, power unit with single diesel engine drive.

After the temporary legs of the Texas Tower have been lowered to the Atlantic's floor, the job of raising this immense "island" platform weighing approximately 10,000,000 pounds, above the ocean level, begins . . . and dependable H-P-M hydraulics were chosen for this important task. Up it goes—approximately 55 feet above the sea . . . slowly, carefully, on the three supporting columns. Each column is independently controlled, hydraulically, so that leveling is simplified regardless of the condition.

Not everyone faces this kind of engineering problem. Not everyone needs an immense power source such as this. But if DEPENDABILITY is your problem—rely on H-P-M hydraulics for the answer. Pumps, valves, cylinders for every heavy requirement.

HYDRAULIC POWER DIVISION
THE HYDRAULIC PRESS MFG. CO.
Mount Gilead, Ohio, U.S.A.
A DIVISION OF KOEHRING COMPANY

HPM

NFPA NATIONAL FLUID POWER ASSOCIATION

Men of Machines

since 1954, Mr. Peterson succeeds **Edward T. Peterson,** who is continuing with the company as senior engineer.

Vickers Inc., Detroit, has named **Louis G. Jordan** assistant chief engineer for industrial products and **Carl A. Brown** assistant chief engineer for automation systems. Both men have been associated with Vickers for more than 20 years. Mr. Jordan has specialized in hydraulic piston pump, motor and transmission design and development; and Mr. Brown has been associated with design and development of special hydraulic machinery and devices.

Jack Rosenberg has been appointed manager of automation by Electronic Control Systems Inc., Los Angeles, an affiliate of Stromberg-Carlson Co. and a subsidiary of General Dynamics Corp. Mr. Rosenberg will be responsible for the design, development and prototype construction of high-speed, special-purpose digital computers and controls for machine tools.

Parker Appliance Co., Cleveland, has announced the appointment of **William G. Webster** as chief engineer for the Cleveland Div. of Parker Aircraft Co., Los Angeles. Mr. Webster joined Parker as a test engineer in 1951 and has served as design engineer and project engineer.

Willy A. Fiedler, who has worked on missile projects for the United States Navy during the last eight years, has been appointed to the engineering staff of the Lockheed Missile Systems division. He has been assigned to a research and development post in the advanced design division of the engineering branch, with headquarters at Lockheed's San Jose, Calif., office.

AC Spark Plug Div. of General Motors, Flint, Mich., has formed an engineering group to develop pneumatic-powered components for the automotive industry. Head of the group will be staff engineer **Gordon W. Harry,** who has been associated with the AC division

since 1925, most recently in charge of the fuel pump engineering section. He will continue to serve that section as a consultant. **Gordon B. Elder,** formerly senior project engineer, has been promoted to staff engineer and will assume Mr. Harry's former duties.

Chedo P. Graham has been named chief engineer by Aro Equipment Corp., Bryan, O. He has been assistant chief engineer since January, 1954. Mr. Graham

Chedo P. Graham

has served in various engineering positions with the Airplane Div. of Curtiss-Wright Corp.; L. W. Ross & Co., consulting engineers; and Stewart-Warner Corp.

J. L. Biasetti has joined the Hercules Motors Corp., Canton, O., as an executive engineer. He was previously associated with Cummins Engine Co.

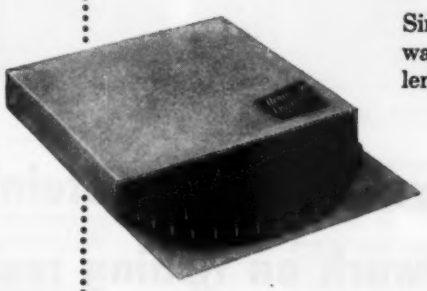
The Magnavox Co., Fort Wayne, Ind., has appointed **R. H. Severance** chief engineer of its newly created Urbana, Ill. division. Mr. Severence joined Magnavox in 1937. For the last eight years he has been chief engineer of the Special Devices Section.

Robert J. Mudd has been appointed assistant engineer in the office of the director of electrical engineering at Allis-Chalmers Mfg. Co., Milwaukee.

off the shelf service of ACME Precision Chains saves you time and money!

Your Acme Distributor has the chain you need

RIGHT IN STOCK—ON THE SHELF!



Single strand roller chain is always available in 10 and 25 foot lengths at your Acme distributor. Neatly packaged in clean convenient cartons, plainly marked for easier handling and shipping. Packaging eliminates dirt, prevents damage to chain. Available in all standard sizes. Another Acme service you'll find most useful and economical. Reels also available for handling large quantities of Acme Chain. See your Acme distributor.

FREE CHAIN CATALOG

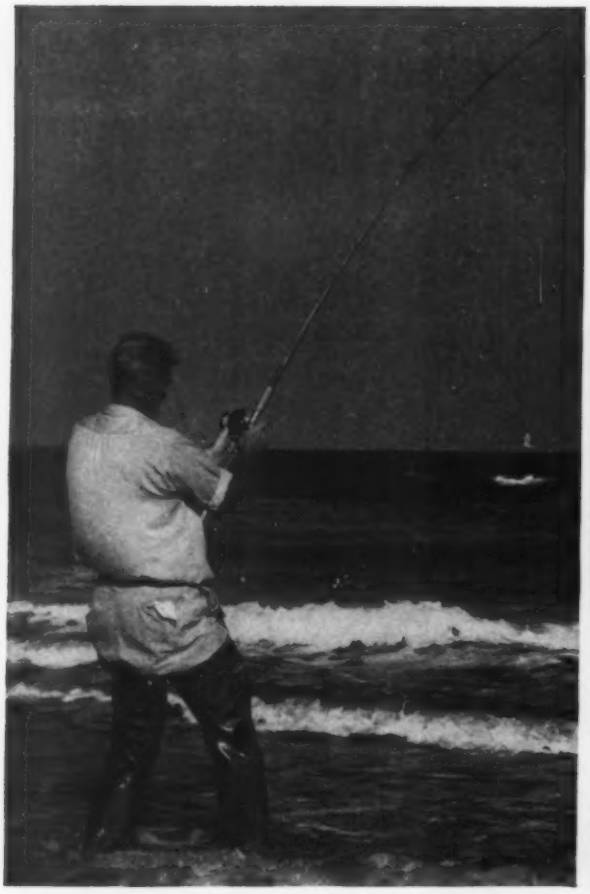
Write Dept. 6-G for your 80-page copy of Acme's latest catalog. Packed with valuable chain data. An indispensable chain reference.

Call ACME for Service

Acme Chain Corporation

HOLYOKE MASSACHUSETTS

Circle 521 on page 19



Carpenter Free-Machining Stainless eliminates expensive handwork on fishing reel shaft

Excessive burrs when machining this level wind shaft for a fishing reel were constantly interfering with maximum productivity. Other important factors on the job are good corrosion resistance, and long wearing qualities.

Seeking improvement not only in the product, but also in its manufacture, the company decided to try Carpenter Stainless No. 5 (Type 416). The results were exactly as anticipated . . . easier, more uniform machining properties and burr-free finishes took the job out of the doubtful class and made it a profitable operation. No. 5 eliminated expensive hand work on the shaft, and put this job on a profitable, productive basis.

If you're not now using Carpenter Free-Machining Stainless, here's a real opportunity to improve production of stainless parts and products. For immediate delivery, call your nearest Carpenter Mill-Branch Warehouse, Office or Distributor.

Carpenter STEEL

Free-Machining Stainless Steels

The Carpenter Steel Company, 120 W. Bern St., Reading, Pa.

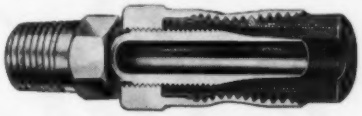
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

WEATHERHEAD

First in components for HYDRAULIC SYSTEMS

Look at anything . . . anywhere in the world . . . in hydraulics, diesel power or machine tool applications . . . equipment for instrumentation, oil drilling, mining, road building, petro-chemicals or even atomic power . . . chances are the vital air and fluid lifelines are secured with WEATHERHEAD.

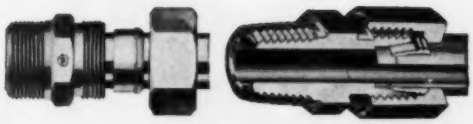
Reusable Hose Ends



Bulk Hose

Hose Assemblies

ERMETO



SAE 37° FLARE

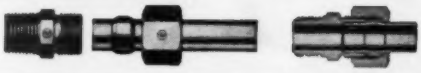
3-PIECE

2-PIECE

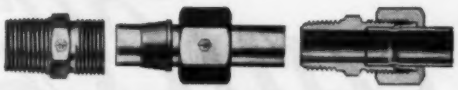
SAE 45° FLARE

INVERTED FLARE

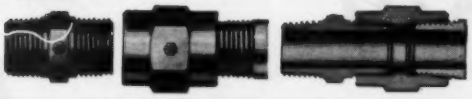
COMPRESSION



SELFALIGN



PIPE



DRAIN COCKS

WEATHERHEAD
FIRST IN HYDRAULIC CONNECTIONS

THE WEATHERHEAD CO., FORT WAYNE DIVISION
Dept. AB-11, 128 West Washington Blvd., Fort Wayne, Indiana
In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

WEATHERHEAD
The only single-source hydraulic hose and fitting line.
Available coast-to-coast through Weatherhead distributors.

Circle 523 on page 19

XUM

Manganese helps ease the squeeze on Stainless Steel!

METALS DO MORE ALL THE TIME

Important facts about a new and plentiful family of low-nickel Stainless Steels!

Now in plentiful supply, the new "200" Series Stainless Steels permit steelmakers to greatly expand their output of Chrome-Nickel stainless from existing nickel supplies. With the addition of manganese, the nickel content can be cut in half to provide practical, workable stainless steels that can be applied to a wide variety of uses.

The "200" Series is meeting the constantly expanding needs of the transportation, building, manufacturing and many other fields. It's becoming increasingly popular for use in kitchen utensils, appliances, truck bodies, trains, automobile trim, hospital equipment and scores of other consumer products.

For further information, see your stainless steel supplier, or write ELECTROMET—leading producer of chromium, manganese, and more than 100 alloys for the steel and other metal industries.

ELECTRO METALLURGICAL COMPANY

30 East 42nd Street UCC New York 17, N.Y.

A Division of Union Carbide and Carbon Corporation

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Electromet

The term "Electromet" is a registered trade-mark of Union Carbide and Carbon Corporation

. . . THANKS TO ALLOYS

Circle 524 on page 19

XUM

Simple Arithmetic...
Type 302, Sheet Base Price 47.50 cents per lb.
Type 430, Sheet Base Price -36.75 cents per lb.
Saving 10.75 cents per lb.
in Stainless SHEET Costs!

Now you can SAVE $215 per ton in base price alone!

Many designers and fabricators who are currently using Type 302 stainless can, in numerous applications, specify Type 430 straight chromium stainless and take advantage of the 10¾ cents per pound difference in base price. Some of our customers are already saving more than $215 per ton using our 430 MicroRold stainless sheet.

The steel industry estimates that 50% of all stainless sheet applications could satisfactorily employ Type 430, the least expensive of all stainless grades, as an economical and practical material. When properly applied, Type 430 has all the desirable qualities of beauty, corrosion resistance, strength, long life and low maintenance that no other material, except stainless, can offer.

We are currently producing our MicroRold Type 430 sheets up to 48" wide in thicknesses .005" to .109" with 2B or 2D finishes; and in thicknesses .010" to .109" in No. 3, 4 and 7 finishes.

Send for Your copy, "Care and Use of 430 MicroRold Stainless Steel"

Washington Steel *Corporation*

11-E WOODLAND AVENUE, WASHINGTON, PA.

Multiple sources for "Things" not called SPRINGS

Yours to put to work . . . . our mechanical ingenuity and craftsmanship . . . . experienced in producing an infinite variety of metal parts in such fields as automation, communication, medical, electronics, safety devices, product development, etc. The capacity of ASC springmaking minds and machines is unlimited. Ask any Division to examine your sample or blueprint.

Divisions of

ASSOCIATED SPRING CORPORATION

XUM

Titanium Tubing

For processing lines carrying fluids of an extremely corrosive nature — look to *Contour Trentweld* titanium tubing for reliable service.

This titanium tubing is completely uniform throughout any cross-section. The weld zone is free from bulging weld bead because Trent's exclusive process — performed with the weld area at the bottom — forms the molten weld metal into the shape of the tubing.

And, with titanium, you get the unique advantages of a tubing that's strong as steel but 44% lighter . . . virtually immune to a broad spectrum of corrosive materials . . . entirely free from stress-corrosion cracking.

So, next time you need a strong, light, extremely corrosion-resisting tubing—try *Contour Trentweld* titanium tubing. And remember, it's made by Trent — tube mill specialists.

CONTOUR TRENTWELD

Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

Now you can get from PROGRESSIVE Slotted Tapping Screws with an extra customized touch — Slotted Tapping Screws which are custom-made to your order. This means: (1) specifically made for you — not bin stock parts; (2) fast, custom-handling of every order; *plus* (3) the double economy of low initial cost *and* the savings in your assembly operations possible only with high precision, torsion-tested fasteners.

STANDARDS AND SPECIALS CUSTOMIZED FOR YOUR NEEDS

THE PROGRESSIVE MFG. CO.
Division of The Torrington Company
52 Norwood Street, Torrington, Connecticut

Circle 528 on page 19

Circle 529 on page 19→

XUM

GENERAL ELECTRIC ANNOUNCES

static switching systems

General Electric's new static switching systems have been designed to increase significantly the dependability and life of control equipment where frequent operations, complex systems, and continuous processes are required or atmospheric problems exist.

These new G-E systems utilize static-magnetic and solid-state devices to perform a variety of control functions normally accomplished by contact-making devices. Static switching systems consist of varied combinations of seven basic units: an isolation switch unit, two multi-purpose units, a long time-delay unit, a short time-delay unit, an "AND" unit, and an "OR" unit. These units can also be combined with static power supplies, static amplifiers, and static regulators to provide completely static control systems.

Where frequent operations are involved, static switching systems are ideal, as they have no moving parts to wear.

Where complex control functions are required, the simplified circuitry of the static switching systems makes them particularly applicable.

For continuous processes, these systems assure dependability through the use of pre-tested, industry-proved static components.

Unaffected by most atmospheric conditions, the static units are encapsulated in an inert, lightweight compound.

General Electric control engineers are ready now to help you apply the benefits of static switching systems to your machines or processes. For additional information, contact your nearest General Electric Apparatus Sales Office, or write for Bulletin GEA-6364 to Sect. 785-2, General Electric Co., Schenectady 5, New York. *Industry Control Dept., Roanoke, Virginia.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

XUM

A Challenging Engineering Opportunity . . .

Technical Editor Wanted

• Here is your chance to gain a broad knowledge of the design engineering field and related activities.

• Edited for engineers, by engineers, MACHINE DESIGN has an opening on the editorial staff for a man with enthusiasm both for engineering and for writing and editing.

• He will work on a stimulating job that provides interesting contact with diversified problems in a variety of engineering areas.

• Additionally he will be encouraged to progress as a specialist in one or more of the branches of design engineering.

• He should have had some design experience, and an EE or ME degree would be desirable.

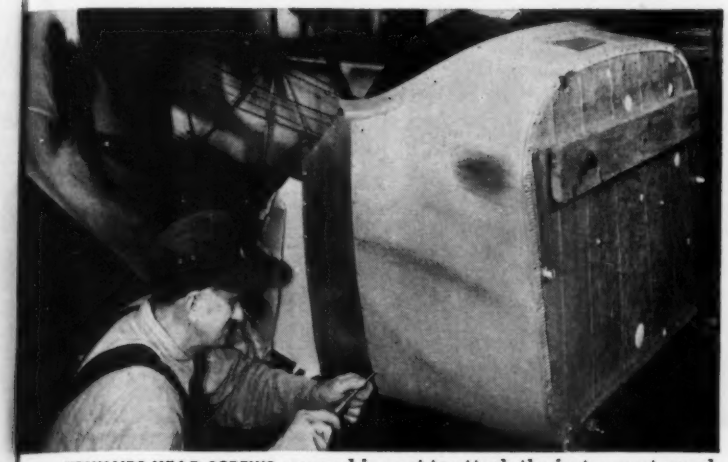
• He should be able to write fluently and well, and should show evidence of such ability.

• Duties include the procurement, selection, writing and editing of articles and feature departments.

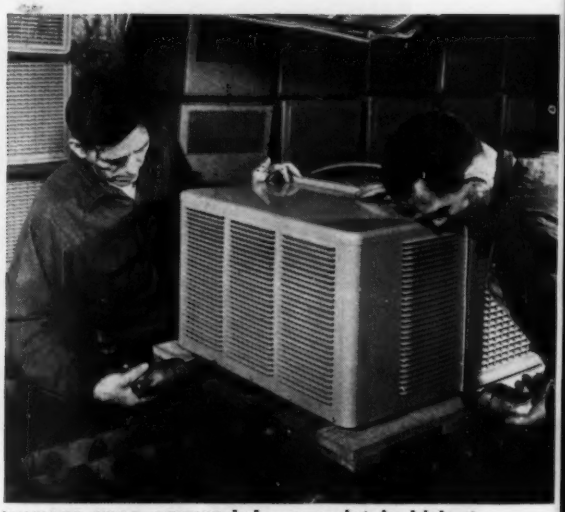
• Headquarters are in Cleveland, with opportunities for travel to attend meetings and expositions and to seek material for publication.

• If you are interested and feel qualified, send full details of your engineering and writing experience to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

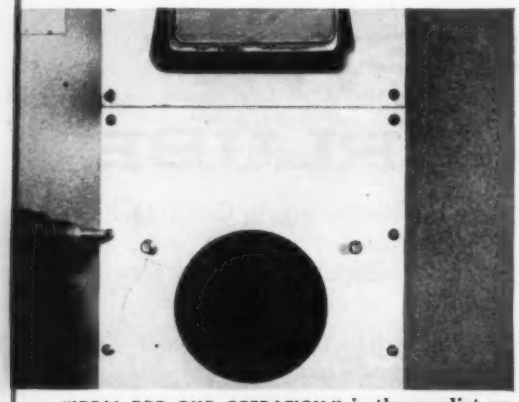
Neater, Better, Faster Assemblies with PHILLIPS CROSS RECESSED HEAD SCREWS



"PHILLIPS HEAD SCREWS are used in part to attach the instrument panel, inspection panels, compartment panels, wing tips, electrical panel and landing gear fastenings," says Mr. Counsil, a purchasing agent for the Piper Aircraft Corporation of Lock Haven, Pa. "In fact, it would be difficult to find any place in the plane where Phillips Head screws are not being applied."



"PHILLIPS HEAD SCREWS help us maintain highest quality and quantity," states Mr. W. E. Zielonka, plant manager of the Fedders-Quigan Corporation, Buffalo, N. Y., makers of famous Fedders room air conditioners and other products. Mr. Zielonka continues: "Our assembly line employees are the best salesmen for Phillips screws. They're paid by piece work, and fast, non-slip driving of screws means a lot."



"IDEAL FOR OUR OPERATION," is the verdict on Phillips screws at the Indianapolis plant of the Bryant Division of Carrier Corporation, world's largest producers of automatic heating units. "Phillips screws are terrific time savers, cause less waste and damage and give much tighter fit," reports Mr. Al Barnett, foreman of the Bryant general assembly department.

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY...
AND OF THE FUTURE
X marks the spot
the mark of extra quality

Pledged to highest standards...

The Phillips Screw manufacturers listed here cooperate to turn out a uniformly high standard of quality. As sponsors of the Phillips Cross-Recessed-Head Standards Committee they adhere to the established dimensional standards, gauges, and gauging methods which will best serve industry.

Members of Screw Research Association

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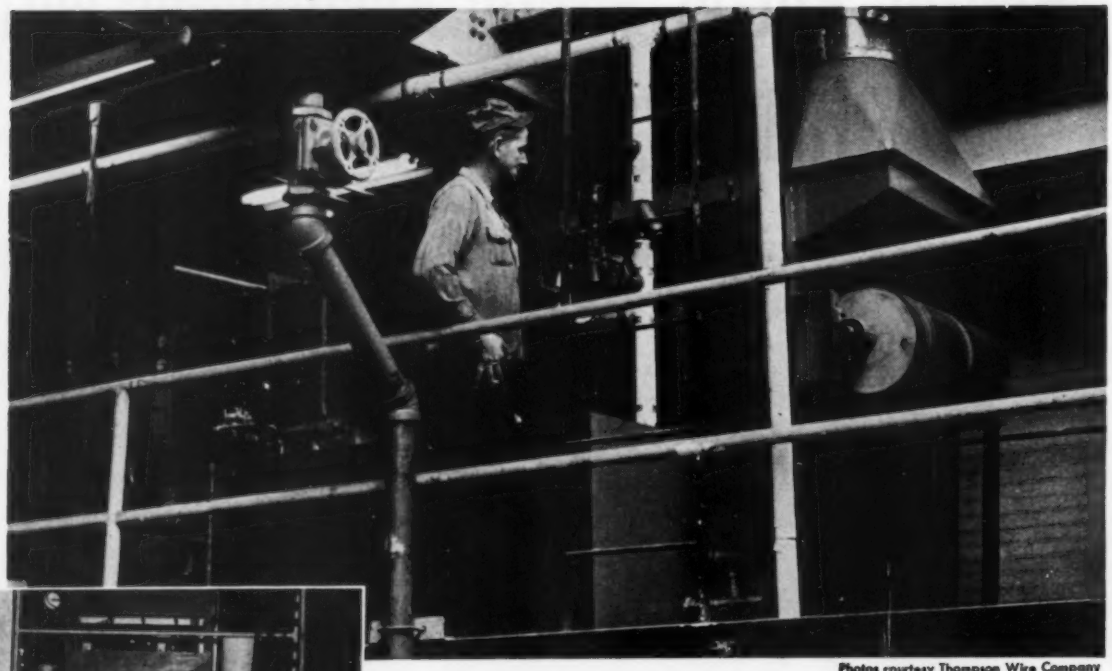
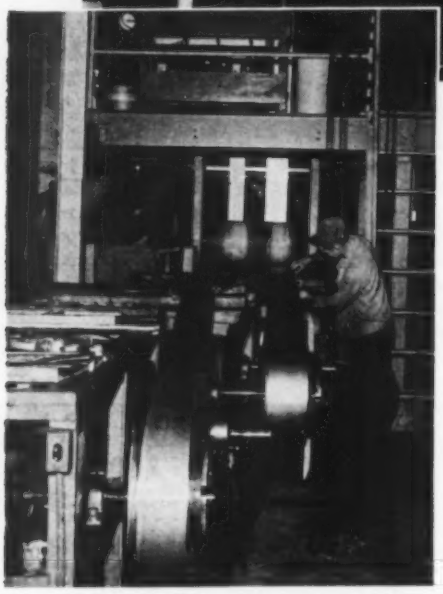
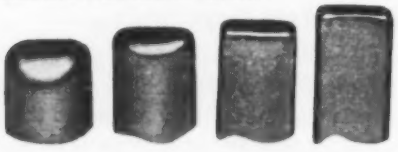
XUM



Photos courtesy Thompson Wire Company



Above (right)—In this continuous installation, strip steel is treated with Bonderite, then with Bonderlube lubricant. *Below*, treated strip is re-coiled as it comes out of the machine, Bonderite-Bonderlube treated.



Successive steps in forming a small case from Bonderite and Bonderlube treated strip.

For better performance in the forming dies . . .

Get steel strip, mill-treated with

BONDERITE *and* BONDERLUBE

Here's a service that can mean real savings in your cold forming operations. Buy mill-treated steel, in coils, treated with Bonderite and Bonderlube and ready for the dies.

This specially treated strip, with its Bonderite-Bonderlube coating, is used for many products and components made by cold forming. The combination of Bonderite and Bonderlube provide such effective lubrication that severe deformations are possible without marring surface finish. Tools and dies last longer, production may be greatly increased, production costs are reduced.

Investigate mill-treated steel strip with Bonderite and Bonderlube. Ask your strip supplier about this new development.

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

PARKER RUST PROOF COMPANY

2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914— leader in the field

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

How to make your automatic heat-treating and hardening even more automatic

...at no extra cost

FAST, continuous operation is the key to profitable automatic forging production lines. Especially in high speed heat-treating and hardening operations. They're extremely sensitive to changes in chemical composition and structure of steel used. Interruptions to make tests or adjustments slow production, increase costs, reduce the advantages of automatic operation. This makes the uniformity of the steel you use an even more vital factor. The more uniform the steel, the steadier the production and the greater the potential you can realize from your automatic equipment.

You can get the utmost in uniformity, and automatic operation—at no extra cost—by using Timken® fine alloy steel. Uniformity is constant from bar to bar, heat to heat, order to order.

We take many extra quality-control steps to assure this uniformity. For example, the Timken Company uses a magnetic stirrer for molten steel to assure equal distribution of alloys, uniform temperature and improved working of the slag. It's the first installation of its type in the United States.

To further assure uniformity, your order of Timken fine alloy steel is handled individually. We target our conditioning procedures to meet your end use requirements. Each bar is stamped to identify the heat it came from. This limits variations within an order as well as from order to order. And every heat is examined spectrometrically to insure uniform grain size.

To make your automatic heat-treating and hardening operations even *more* automatic—at no extra cost—always specify Timken fine alloy steel. You'll get money-saving performance and uniform results every time. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 533 on page 19

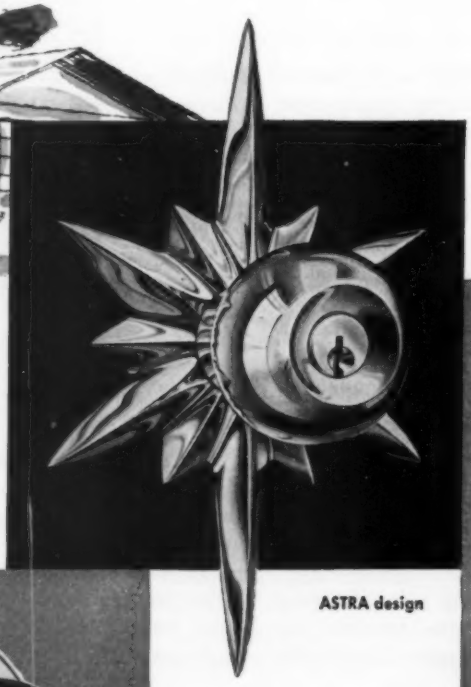
XUM

MUELLER BRASS CO.

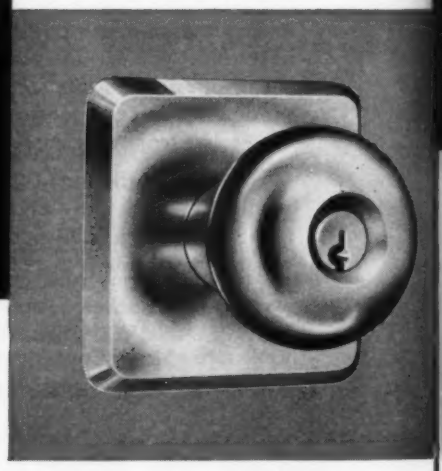
brass and bronze forgings help insure dependability and lasting jewel-like finish of distinctive SCHLAGE locks

Smart styling, handsome appearance and durability have been neatly combined by the Schlage Lock Company of San Francisco in their line of lock designs for residential and commercial use. Many important parts of these lock sets are brass and bronze forgings made by the Mueller Brass Co. The beautiful natural color, corrosion resistance, and inherent dependability of these forgings make them ideal for this purpose. In addition, the high degree of surface smoothness makes possible an exceptionally lustrous finish as well as a perfect plating surface when required. Then, too, the use of forgings has reduced costs, cut finishing time and greatly reduced the number of rejects when compared to the sand castings that were formerly used.

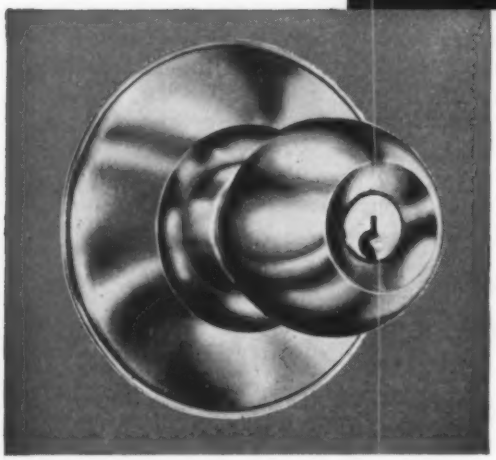
Whether you manufacture decorative hardware where finish is of prime importance or rugged assemblies that must stand up to bruising everyday punishment, it will pay you to investigate Mueller Brass Co. forgings. Strong, long wearing brass, bronze or aluminum parts, forged to your exact specifications under exacting statistical quality control standards can help you reduce costs, improve performance, and give you a better looking product. Write for our engineering manual (No. H-58565) . . . or call in one of our engineers to investigate possible forging applications in your products.



ASTRA design

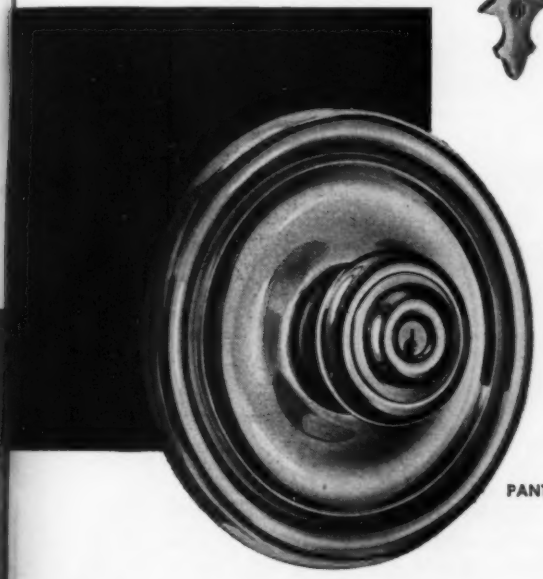


MONARCH design



MERCURY design

WAVERLY design



PANTHEON design

METALS AND ALLOYS REVIEW

by FRANK M. LEVY
Vice-President and Director of Research

Last week one of our sales engineers was at the home office and we were talking about one of his customers in the East who manufactures milling machines which are being used for milling aircraft spars. We are supplying gibs, slide bars and wear strips to this company made of our "600" series bearing metal in rectangular rod form. The material formerly used was aluminum bronze* cast bars which they could only obtain in 36" lengths. Their engineering department estimates that costs have been reduced 50% on this component. Machining time has been reduced and impregnation of porous castings has been eliminated.

Our sales representative was curious about my experience with "600" in other applications such as this. Oddly enough, our own plant has been a pretty good proving ground. In our extrusion department, for example, we have gotten exceptionally good service from slides made of "600" and used on the die heads which are subject to pressure and extremely rough usage.

Bob Irwin of our forging department reports that the "600" strips he has used for lining the ways of our big forging presses have proved far superior to the bronzes which were original equipment. The bronze strips squashed out after protracted running. More important, the "600" strips last 10 times longer before replacement is necessary.

In our copper tube fabricating department we have a lot of automatic equipment for the production of formed tube shapes like tees and ells used in the plumbing industry. On one of the tube benders, there was no provision made for replacing worn forming slides. Our Maintenance Department reworked the machine using "600" strips as replaceable forming slide inserts. The bender is now a far more efficient machine. Because of the long life of "600", downtime on this machine has been practically eliminated.

While we were talking about these uses in our own plant, it brought to mind some other instances where the exceptionally good wearing properties of "600" have been established. A Cincinnati lathe manufacturer uses "600" in the form of counter sunk hex-headed screws on wearing strips used on lathe carriages. When the strip wears to the retaining screw the ways will not be scratched.

According to their own records, all other materials which they had tested proved unsatisfactory for the job. Another maker of precision lathes and milling machines found that after a year of exhaustive tests, the "600" metal that was used as nuts on compound slide screws outlasted competitive metals at an approximate ratio of 3 to 1 at an estimated saving of 30%.

Sliding surfaces on all kinds of machinery have different wear characteristics, as you have undoubtedly found. If you have any problems involving gibs, slide bars or wear strips that are proving troublesome, why not drop me a line or send a part print and we'll be glad to study it and make the proper recommendations.

**We manufacture 4 grades of wrought aluminum bronze.*

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings
Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys
Engineering Manual H-58563 ☐

600 Series Bearing Alloys
Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form
Engineering Manual FM-3010 ☐

MUELLER BRASS CO.

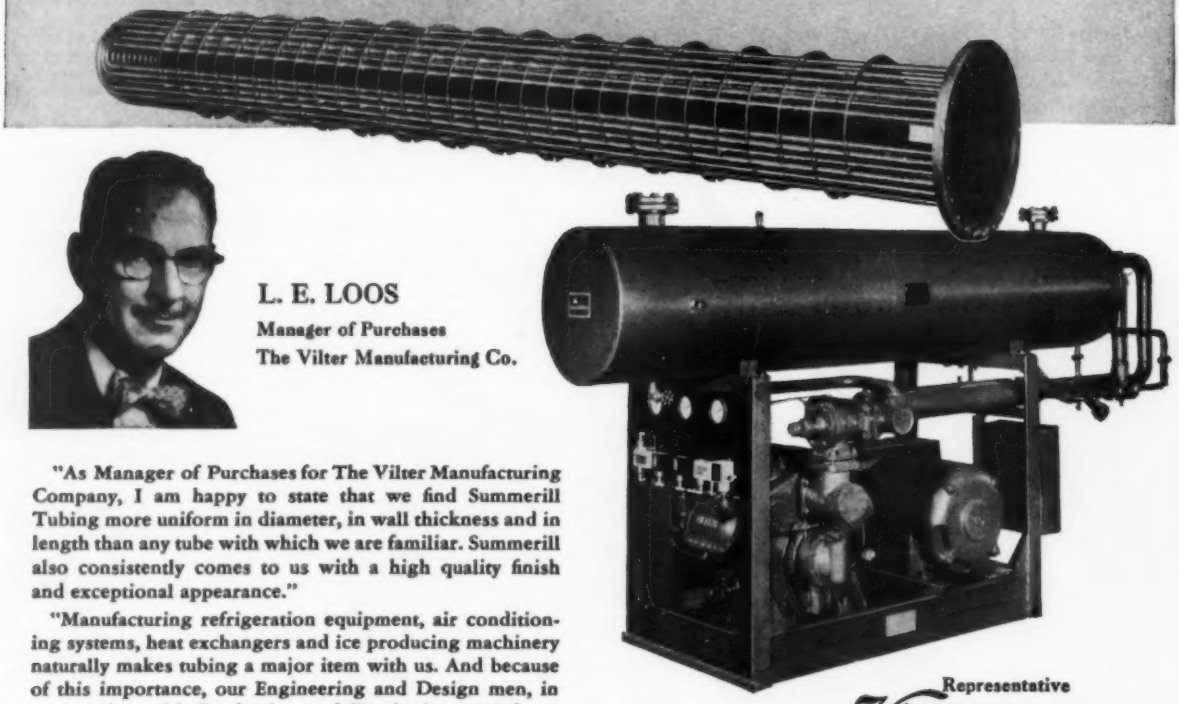
PORT HURON 15, MICHIGAN

185

XUM

"We Have Found a Difference in Condenser Tubes"

"Exceptional size uniformity in Summerill Tubing led to major cuts in our production costs."



L. E. LOOS
Manager of Purchases
The Vilter Manufacturing Co.

"As Manager of Purchases for The Vilter Manufacturing Company, I am happy to state that we find Summerill Tubing more uniform in diameter, in wall thickness and in length than any tube with which we are familiar. Summerill also consistently comes to us with a high quality finish and exceptional appearance."

"Manufacturing refrigeration equipment, air conditioning systems, heat exchangers and ice producing machinery naturally makes tubing a major item with us. And because of this importance, our Engineering and Design men, in conjunction with Production and Purchasing, spend unlimited time specifying, selecting and testing tubing."

"We build thousands of tube bundles similar to the one illustrated above, and using uniform Summerill Tubing means there is no need to selectively ream and re-ream each hole in the tube sheet to fit an individual tube. A Summerill Tube is also seated with one rolling operation and a single size of tool. There is added significance here if you count the 136 holes in this typical sheet. Repeating any of the reaming or seating passes immediately multiplies into a serious cost problem."

"Summerill Tubing is our recommendation because we have found a difference in the degree of uniformity in condenser tubes."

L. E. LOOS

Representative
Vilter UNI-CHILLER

There is little we would add to Mr. Loos' report on the dollar-and-cents-importance of specifying quality steel tubing by the name . . . SUMMERILL. All Summerill Tubing is produced under the meticulous supervision of our metallurgical laboratories.

There is a complete range of sizes of Summerill carbon and alloy tubing to meet your most demanding specifications. Be the person responsible for a step that can effect major cuts in production costs for your firm. Write for complete information on Summerill Seamless Steel Tubing . . . today.

Summerill Tubing Company Division-Columbia Steel & Shafting Co.

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These exceptional advantages have kept OEM users specifying Baldor Streamcooled Motors for over a third of a century.

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Keeping production on the move with Westinghouse pushbuttons

On Ford assembly lines, automation starts with the press of a button. From the paint line (shown), 18 different body styles are automatically guided to various trim lines. As each body passes the operator, he channels it to the proper trim line simply by pressing a button.

In textile mills, steel, paper or fabricating plants, Westinghouse pushbuttons are also on the job, guiding smooth-functioning lines of material to finished product stages. Doing it faster, better, and at a lower operating cost to you than ever before possible.

From Westinghouse you can get precisely the right operator, enclosure, whatever you need—when you need it. Complete lines of standard-duty, heavy-duty, and Oil-Tite* pushbuttons are stock items with Westinghouse.

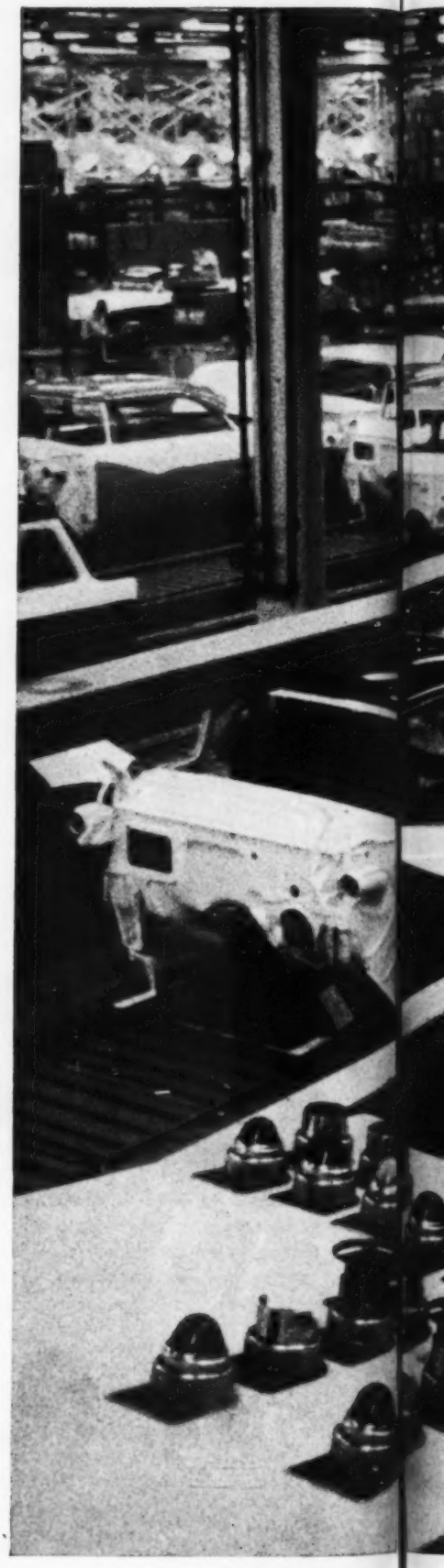
Write to Westinghouse, Box 868, Pittsburgh 30, Pa., or see your nearby Westinghouse distributor for a copy of the new *Pushbutton Guide*, B-6749.

*Trade-Mark

J-30229

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***



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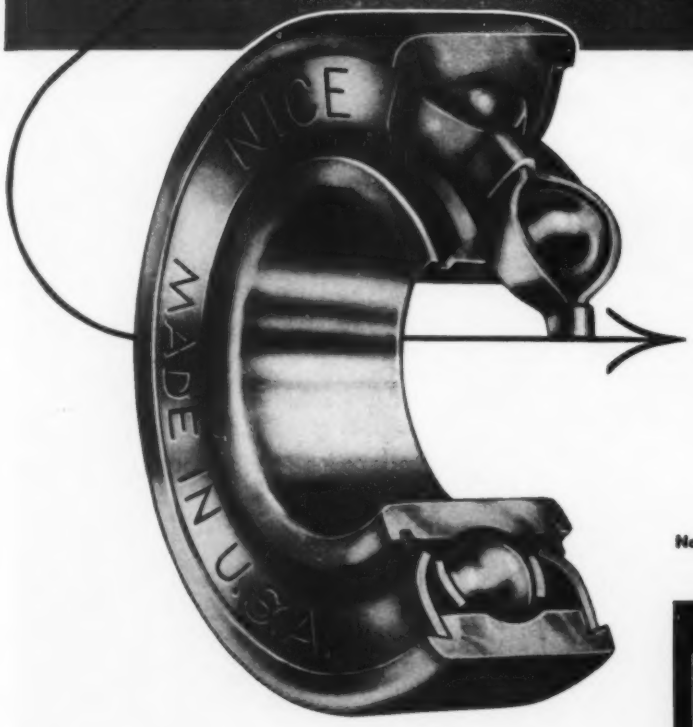
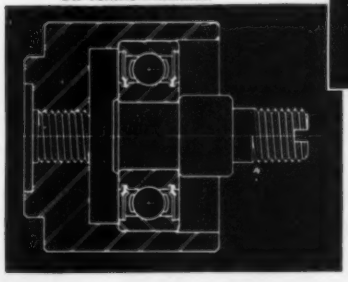
NICE IS THE WORD FOR BEARINGS

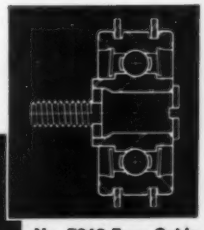


"1600" Series Precision and "3000" Series Unground "Precision Type", Composition Sealed.

The NICE line of ball bearings includes over 750 sizes and types of standard bearings and more than 2500 "specials". This provides a wide range of precision, semi-precision, and unground bearings available to the product designer. If a new "special" is the functional or economic answer to the problem, NICE engineers can design a bearing that will be exactly right for the particular application.



No. 7061 Spindleless Attachment For Spool Winding On Textile Machine.



No. 7069 Tape Guide Roller For Business Machine.

Write for Catalog No. 150

NICE

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA

Circle 538 on page 19

How Aeroquip Flexible Hose Lines Simplify Fluid System Design and Installation

TYPICAL AEROQUIP HOSE TYPES AVAILABLE

Aeroquip 1503 and 1502 Single Wire Braid Hose and Reusable Fittings are recommended for medium pressure hydraulic, lube and fuel oil, water and air lines up to 3000 psi. Sizes from 3/16" to 3".

Aeroquip 1509 Double Wire Braid Hose and Reusable Fittings are recommended for high pressure hydraulic, grease, fuel and air lines up to 4500 psi. In sizes from 1/4" to 2".

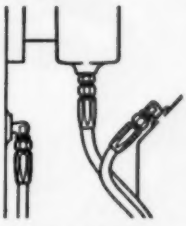
Aeroquip 2802 Teflon Hose and Reusable "*super gem*" Fittings are recommended for chemical, steam, hot asphalt and other corrosive fluid lines. In sizes from 1/4" to 1".

Aeroquip 1525 Cotton Braid Hose and *SOCKETLESS** Fittings are recommended for oil, fuel, air and water lines on engines and other applications up to 250 psi. In sizes from 1/4" to 3/4".
*(Patent Applied For).

Write for full information

SOCKETLESS and "*super gem*" are Aeroquip Trademarks

More simplified and compact fluid system designs can be achieved in many cases through proper application of flexible hose lines. The basic design advantage lies in the fact fewer "parts" are required. A single flexible hose line can be used where elbows, formed tubing sections and assorted adapters are needed using rigid tubing or piping. Flexible hose lines also offer great advantage on fluid systems subject to flexing, vibration and stress.



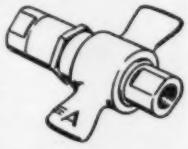
A wide variety of hose types is available to the designer. Aeroquip, for example, now produces 55 different hose types. Some have been developed primarily to carry special fluids. Others have been developed to withstand constant flexing, vibration, surge pressures, extreme temperatures.

REUSABLE HOSE FITTINGS

Aeroquip Hose Lines are unique in that every Aeroquip Fitting is detachable and reusable. In designing fluid systems, reusable fittings offer two advantages. First, mock-ups can be made and modified easily using hand tools to make up hose assemblies. Second, hose assemblies can be quickly made up in production quantities from bulk hose and reusable fittings without installation of expensive swaging machines in a manufacturer's plant. This benefit is also passed on to the equipment purchaser when replacement hose lines are needed. A small supply of bulk hose and a few spare fittings can be used to make quick replacements in the field. Aeroquip maintains an extensive network of distributors to serve users of Aeroquip Hose Lines.

SELF-SEALING COUPLINGS

Where fluid lines or systems require connection and disconnection for periodic inspection or maintenance, Self-Sealing Couplings can simplify design. Replacing two shut-off valves, a Self-Sealing Coupling permits disconnection of lines under pressure without loss of fluid or inclusion of air into the system. Aeroquip manufactures six types of Self-Sealing Couplings, for general industrial use, aircraft systems, Freon systems, LP-Gas fuel tanks, railroad diesel fueling and farm implement hydraulic systems.



FREE ROUTING AND INSTALLATION GUIDE

To help in planning and installing flexible hose lines, Aeroquip has prepared a handy 16-page guide covering flexible applications, bend radii, routing to avoid abrasion, heat damage, flexing failures, etc. Write for your copy today.

Complete engineering assistance is available to manufacturers.

Aeroquip Corporation,
Jackson, Michigan
Please send_____copies
of "Guide for Routing and
Installation of Aeroquip
Flexible Hose Assemblies."

Name_____

Title_____

Company_____

City_____ Zone____ State_____

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

SOCKETLESS Fitting Patents: Great Britain 740,428; France 1,088,423; Austria 185,178—Patents pending in U.S.A., Canada, and other countries.

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

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...do you vote a straight AMERICAN ticket?

There's no real substitute for American-made production machinery in any branch of American industry. Designed and built to take the strains and stresses of the world's toughest demands for speed and endurance . . . with a minimum of down-time and maintenance . . . American machines are today more than ever the best buy in every field from textiles to metal-working. Yes, American production machines are the backbone of America's competitive economy . . . *and why settle for anything else?*

VEEDER-ROOT INC.
"The Name that Counts"
Hartford, Conn. • Greenville, S. C. • Chicago
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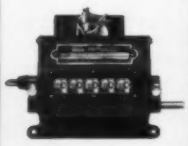
. . . and here's why it pays to make sure that All New Machines you buy are equipped with NEW VEEDER-ROOT COUNTERS...

Modern Veeder-Root Counters are available for *building into* . . . or attaching onto . . . all types of production machines. They are built with unmatched Veeder-Root know-how and quality for years of accurate Countrol of production and uniformity. Ask your Industrial Supply Distributor or write Veeder-Root Inc., Hartford 2, Conn.

Hand Counting: Vary-Tally Multiple Unit Reset Counters for inventory, inspection and 1,001 hand-counting jobs. Up to 108 counters in 1 bank.

Mechanical Counting: Small resets count strokes, turns, pieces . . . are built into machine tools, light presses, etc.

Electrical Counting: Remote indicating counters (AC or DC) bring your production machines as close as your office wall. May be panel-mounted in groups.

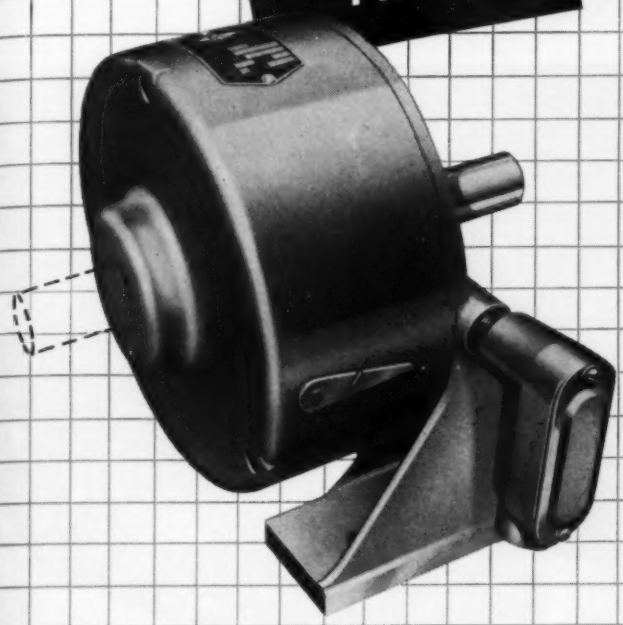


Controlling: Set for number of turns, pieces or operations required. Predetermining Counters control the run exactly . . . prevent over-runs and shortages.

Circle 540 on page 19

Circle 541 on page 19→

Another **REULAND** First!



NEW *REULAND* FOOT-MOUNTED MAGNETIC BRAKE (DISC TYPE) ...COMPLETE with SHAFT and BEARINGS

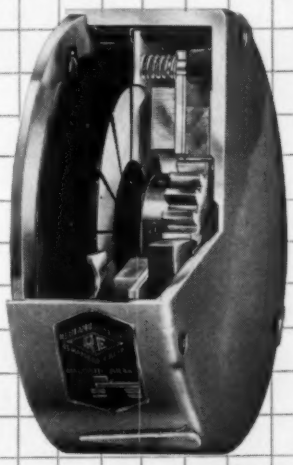
First and Only Disc-Type Brake to fulfill J. I. C. Specifications The efficient, direct-action operating advantages of the Reuland disc type magnetic brake are now available for the first time in this self-contained unit. Being foot-mounted, it can easily be coupled to existing motor or equipment shafts in accordance with J.I.C. specifications. As a standard unit it also can be purchased "off the shelf" by O.E.M.'s or added to equipment at any time by users. Available with either single or double end shaft.

Also available without shaft Reuland disc type magnetic brakes are also supplied for applications where the motor or equipment shaft can be extended directly into the brake. These units are available in both foot-mounted and endbell mounting types. Together with the completely self-contained unit described above, these brakes provide low cost, compact size and efficient operating features that are unequaled.

Reuland Brakes provide great versatility Shaft can be extended entirely through brake, when desired. Also, hook-ups with Reuland Fluid-Shaft motors and Motoreducers permit many J.I.C. and other unique power and braking combinations... combinations that can be tailored to your exact drive requirements without huge, special development costs.

Check these added features

- Automatic lining wear adjustment
- Manual release with automatic reset
- Direct action — no levers or linkage
- One-piece, totally enclosed housing
- One-half usual length — pleasing lines



Cutaway view of endbell mounting type

Other Reuland Firsts

1. Motor with internal fluid coupling
2. Spline coupled hydraulic pump motor
3. All-aluminum motor frames
4. "Xpandable" motor design
5. Slip Ring Motors in small #66 frames
6. "Through-Shaft" magnetic disc brakes
7. Precision motors for machine tools

Use these other REULAND SERVICES...

Special-Motor Library
Don't ever pay for special-motor development costs before you check this free library. Contains valuable data on hundreds of unique specially designed motors. Send for free "how to use" booklet.

Standard Motor Catalog
Contains engineering information on Reuland's complete line of standard motors and motoreducers. Sent free on request.

RE

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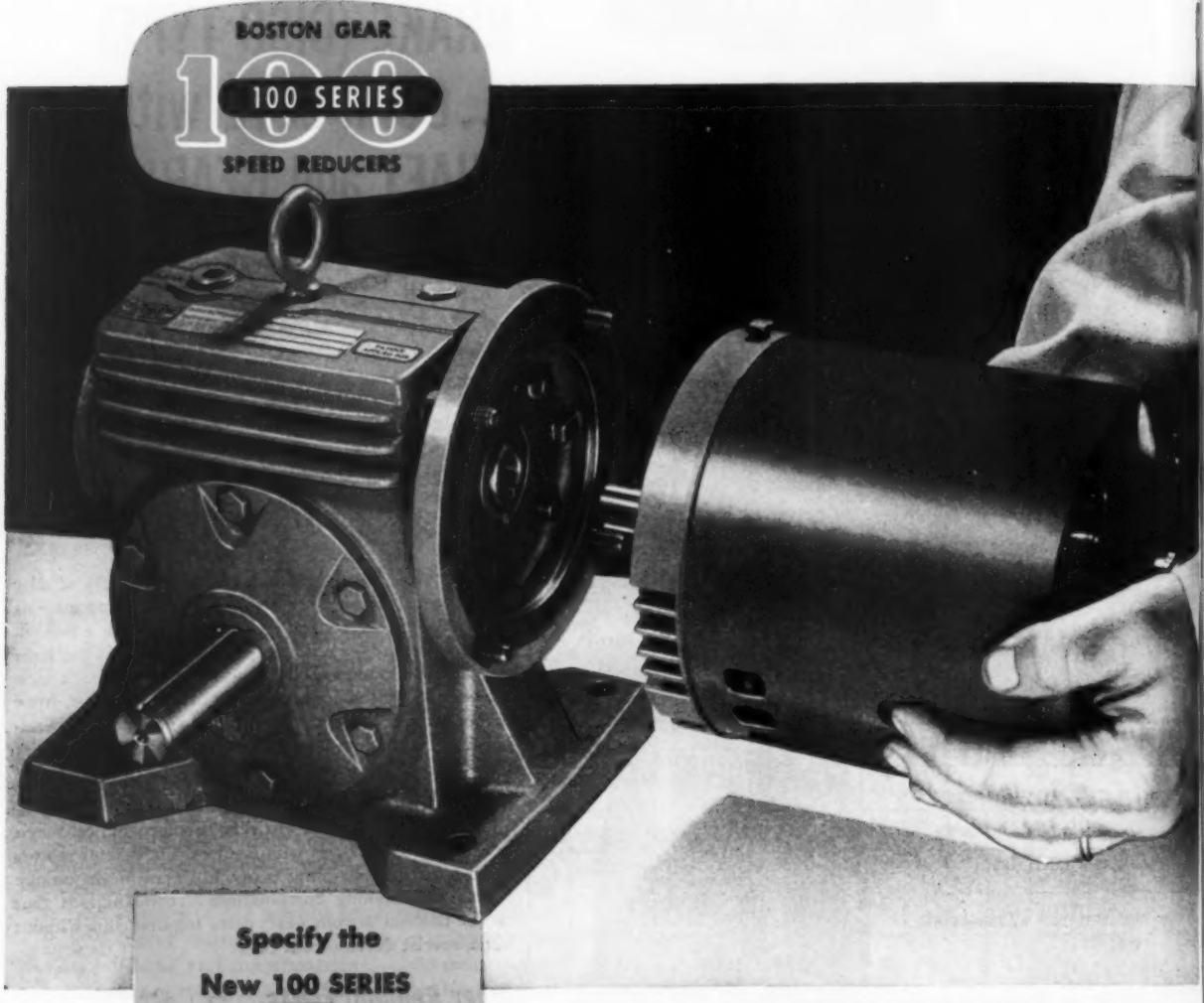
DESIGN AROUND THIS NEW

. . . permits motor change in minutes



Specify the
New 100 SERIES

- SIMPLIFY PLANNING
- SAVE TIME
- GET TOP-RATED QUALITY AND PERFORMANCE

OUTPUT RATINGS
Certified
by INDEPENDENT LABORATORY tests

PATENTS PENDING

BOSTON *Gear*
100 SERIES
REDUCTORS

NEW space saving design
NEW clean contours
NEW gearing efficiency
NEW cooling fins
FAN COOLING optional on larger sizes

COST-SAVING "COMBINATION"

. . . continued operation with spare

No downtime for motor repairs!

The new 100 SERIES RATIOMOTOR combines an independent gear reduction unit and an easily detachable standard end-mounted motor.

MOTOR CAN BE REMOVED AND REPLACED in a few minutes, without disturbing the gear reduction unit. Saves maintenance time, preserves alignment, permits continued operation with spare motor.

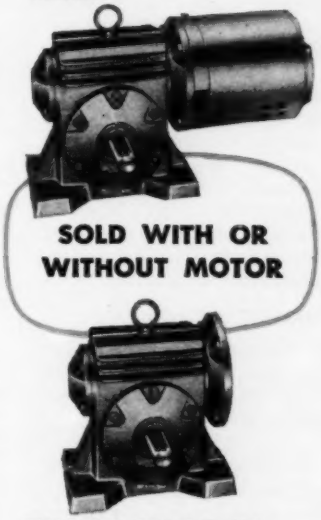
ORIGINAL MOTOR CAN BE CHANGED When conditions require change to a motor of special characteristics (totally enclosed, explosion-proof, etc.) it can easily be attached in place of the original motor.

ANY MODEL YOU NEED — FROM STOCK The new BOSTON GEAR 100 SERIES includes 1605 different units to fit any drive need. Reductors, for mechanical drives, as well as Ratiomotors and Flanged Reductors, are *standardized stock units* sold by BOSTON GEAR Distributors, located in every industrial center of the U. S. and Canada.

TALK TO A BOSTON GEAR FIELD ENGINEER Our 76-year experience as speed reducer specialists will help you simplify planning, and put your product ahead in design. Your Boston Gear Distributor will arrange a call, or write: Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

RATIOMOTORS

The complete power package. Gear unit has fin-cooling and other high efficiency features of new 100 Series Reductors.

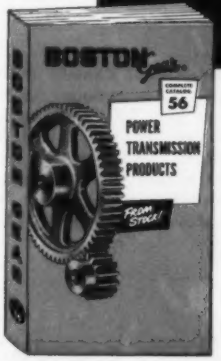


FLANGED REDUCTORS

The Ratiomotor gear unit, supplied without motor. You buy and attach any standard end-mounted motor of your own choice.

1605 DIFFERENT TYPES AND RATIOS — FROM STOCK

Call your **BOSTON** *Gear* **DISTRIBUTOR**



For nearest Distributor, look under "GEARS" in the Yellow Section of your Telephone Directory.

GET NEW CATALOG No. 56

Lists all models of Reductors and Ratiomotors — horizontal or vertical — right angle or parallel — single or double reduction. Includes handy selection charts, engineering data.
Also lists complete information on the full line of 7124 standardized transmission products from stock, for off-the-shelf delivery by your local BOSTON GEAR Distributor.
10-17-56 — 12900 — W. O. 5908

108 MODELS — 1064 DIFFERENT UNITS — FROM STOCK

56-BG-R-17

Circle 542 on page 19

XUM

Tips on specifying timer accuracy

Facts you should be aware of when selecting a timer to meet your accuracy requirements

The application for a timer generally determines the kind and degree of accuracy needed.

If frequent changes are made in the timed interval, setting accuracy is most important. If a machine operation or process occurs again and again at the same timer setting, repeat accuracy is the critical factor. If a timer is factory set for, and operates continuously at, one specific interval, inherent timer accuracy is most important.

Each of these three major types of timer accuracy — inherent, setting, and repeat — calls for different design and manufacturing techniques:

INHERENT ACCURACY

A major factor limiting inherent accuracy is the drive motor. This must (1) be quick starting, (2) be free from coasting, and (3) operate only at synchronous speed. Permanent-magnet synchronous motors meet these requirements better than ordinary clock-type hysteresis motors.

Clutching on a high-speed shaft, close to the drive motor, also increases inherent timer accuracy. High-speed clutching — though more complex and costly than low-speed — should be used on timers in which high accuracy is paramount.

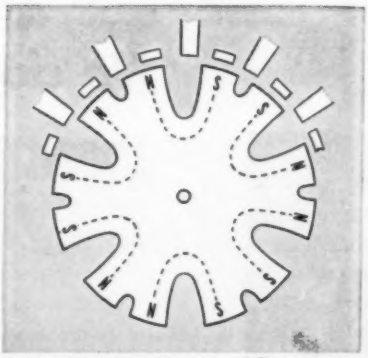
SETTING ACCURACY

Length of dial scale, scale divisions, style of pointers, parallax and distortion due to cover glass, and skill of operators are obvious influences on setting occuracy.

Setting may be of either the friction or vernier (or worm) type. The latter provides good setting accuracies, but lacks the speed and convenience of the friction method. Human errors can often be completely eliminated by use of a factory-set timer.

REPEAT ACCURACY

Shock of operation of a fast reset mechanism — or shock from other causes — can change the timer setting, resulting in inaccurate repeat cycles. This is most likely when the reset and setting mechanisms are combined for reasons of cost. However, by careful design, speed of reset and resistance to shock can be optimized to give the best repeat accuracy.



PERMANENT-MAGNET rotor of Cramer motor (shown here schematically) reaches synchronous speed within two cycles (0.033 sec. at 60 cps) after field is excited, does not coast after power is removed. Most powerful and accurate timing motor available for its size and price.

TECHNICAL HELP AVAILABLE

Cramer field engineers have the answers to most accuracy and other timing problems at their fingertips. They can tell you about Cramer timers with accuracies ranging from 2% to 1/100th of 1% overall. And they'll be glad to discuss your special requirements with you. Get in touch with your local Cramer representative today or write us direct. The Cramer Controls Corporation, Box 6, Centerbrook, Connecticut. 6.11

FOUR WAYS TO SOLVE YOUR TIMING PROBLEMS

NEW TYPE 241 AUTOMATIC RESET INTERVAL TIMER, with full-scale repeat accuracy of ± 1/4 of 1%. Convenient pushbutton start, automatic and immediate reset for electrically operated equipment. Fully described in Bulletin PB-241.

NEW TYPE 412 TIME DELAY RELAY. Positive action ratchet clutch. Repeat accuracy of ± 1/4 of 1%. Introduces timed delay interval between operation of control circuit and load circuit. Ranges: 6 sec. to 24 hrs. Bulletin PB-311.

TYPE 690 TIME TOTALIZER has ± 0.01% accuracy. Totalizes in 1/100th increments to 60 sec. or 60 min. High-speed electro-mechanical clutching. An electrical stop clock for research or production. A-c or d-c models. Bulletin PB-610.

HIGH-TORQUE CRAMER MOTOR, truly synchronous; instant start, stop. 300 speeds, various output shafts available. Torque: 30 in.-oz. at 1 rpm. Permanently lubricated, mounts in any position, UL approved. Bulletin PB-110A.

TALK IT OVER WITH CRAMER

CRAMER CONTROLS
CORPORATION

Circle 543 on page 19

Circle 544 on page 19→

"More Than A Metal—It's A Method"

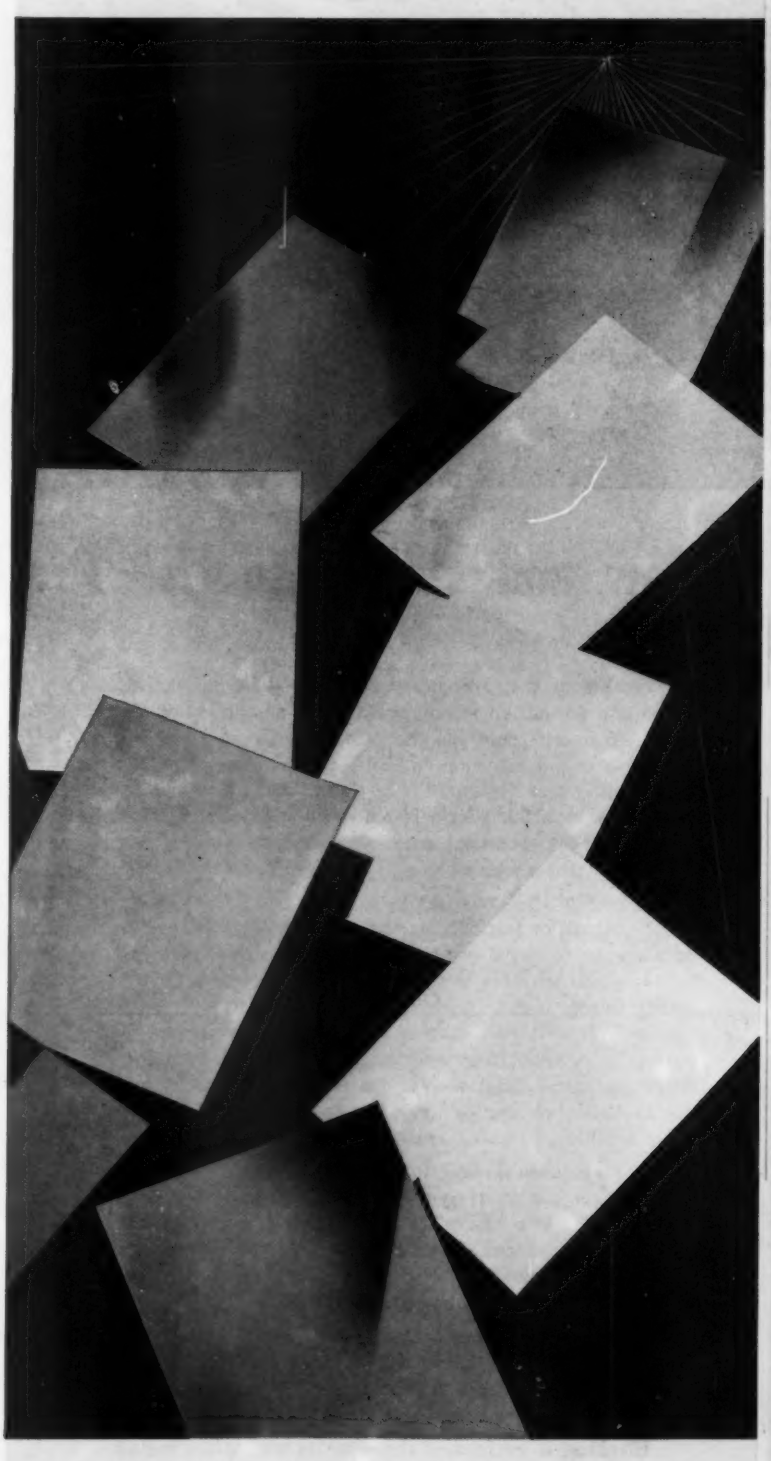
NICKELOID METALS

The Nickeloid Method Eliminates Three Costly Production Steps

Out of the shipping crates — directly into your fabricating process . . . Your production line gets shorter when you take advantage of Nickeloid Metals to produce plated metal components and trim.

Durably, uniformly PRE-plated in 14 finish-to-base metal combinations, these modern metals are ready for immediate fabrication when they arrive at your plant. They require no additional cleaning, plating or polishing — just fabricate and assemble. You by-pass 3 out of 5 basic production steps . . . cut costs up to 20 per cent. Production speed is only one of the reasons why production-minded manufacturers specify Nickeloid Pre-Plated Metals. Improved quality, versatility, functional beauty and the basic production economies of the Nickeloid Method are additional advantages which are being proved every day on production lines in a wide range of industries.

It will pay you to investigate . . . specify Nickeloid Metals.



Nickeloid Metals are available in sheets, coils and strips, with uniform pre-plated finishes of chrome, nickel, copper and brass on base metals of steel, zinc, copper, brass, aluminum.

SEND FOR FREE FABRICATION AND DESIGN BOOKLET

24 pages of illustrations and reference-type material covering uses, properties and fabrication techniques for Nickeloid Pre-Plated Metals.

NICKELOID METALS

SINCE 1898

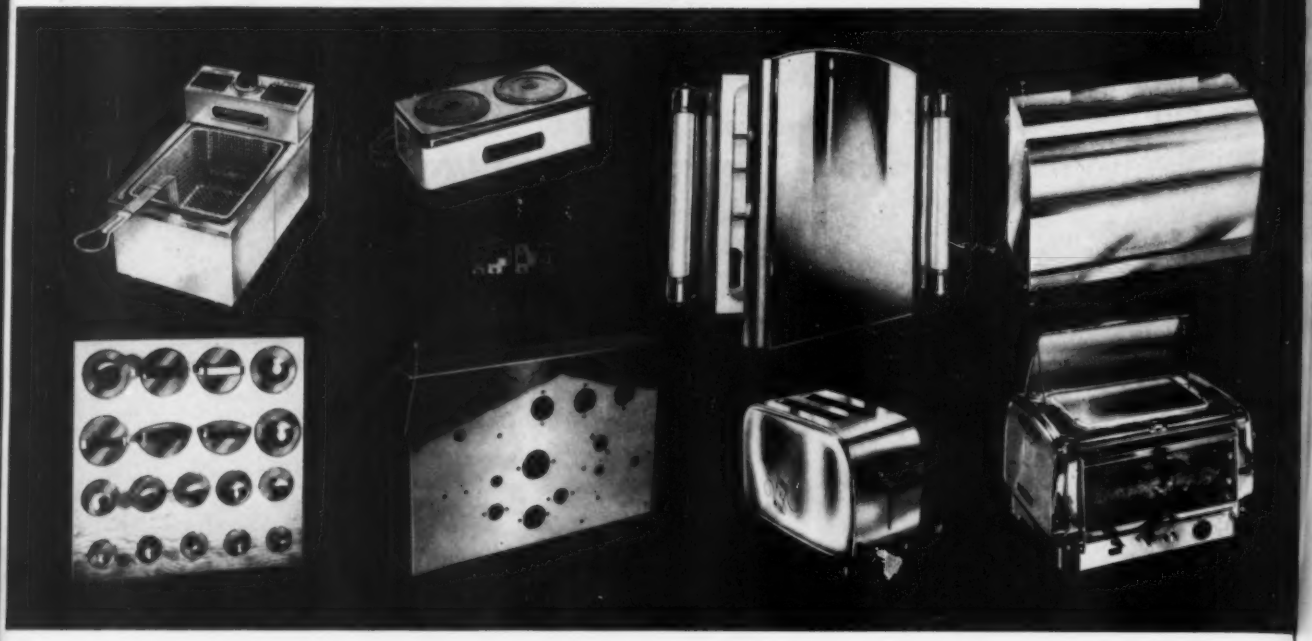
AMERICAN NICKELOID COMPANY

Administrative Office: Peru 8, Illinois

MILLS: Peru, Ill. and Walnutport, Pa.

XUM

Cost-Saving Applications Of Pre-Plated Metals



How and Where to Use Pre-Plated Metals

Because of their versatility and adaptability to various design and production techniques, any list of applications of pre-plated metals could run the gamut from door hardware, striker plates and fish lures to broiler-rotisserie wrap-arounds and cannister sets. Experience has shown that where the design engineer considers a pre-plated metal as his design material in the "pre-planning" stage, these modern *finished* raw materials perform admirably . . . both as eye-pleasing decorative trim and functional parts.

For small or complex parts — for small stampings — or where it is virtually impossible to polish interior and hard-to-reach surfaces and contours, pre-plated metals are ideally suited. Indeed, many design features are conceived "around" pre-plated metals . . . features which would be impossible without the pre-plated method of production. After the part is fabricated it can be assembled right into the finished product — requires no post-plating or organic finishing — no degreasing, washing, rinsing, drying.

The resultant saving in time, manpower and equipment is considerable and quality of output is usually higher and more uniform. Your plating and finishing problems are reduced to merely selecting from among the many finish-to-base metal combinations, the pre-plated metal best suited to your application.

With reasonable care and good shop practice, pre-plated metals can be fabricated in much the same way as unplated metals. There is no need to invest in special handling and fabricating equipment.

Blanking is performed the same as with plain metals except that close inspection of punch and die is required to detect and eliminate rough edges.

In drawing, if the amount of draw is sufficient to cause a dulling or "orange peel" effect on an unplated metal it will cause the same effect on a plated metal. Hydraulic press operation is preferable to mechanical press.

Bends up to 90 degrees can be made with or against the base metal rolling grain without surface dulling, provided that radii are sufficiently large.

Pre-plated metals can also be seamed, welded, soldered, riveted and etched with excellent results.

Where severe forming is required, Nickeloid metals may be furnished with either of two kinds of protective coating, called, Mar-Not. One type is a strippable plastic film which is sprayed on and stretches when the metal is fabricated. The other is a pressure sensitive paper adhered to the metal by a special gum. Either can be easily peeled off after fabrication.

Assistance in designing and fabricating with pre-plated metals — working metal samples, too — is available from **AMERICAN NICKELOID COMPANY.** *See preceding page for free fabrication and design booklet.*

XUM

when the heat's on

...for prompt deliveries
...for reliable quality
...for engineering service

specify **VOI-SHAN**
SUPER ALLOY FASTENERS

Fasteners made of super alloys have become an integral part of jet engines due to their great strength and heat resistance. Satisfactory fabrication of these revolutionary metals has been VOI-SHAN'S pioneering achievement. Major engine manufacturers depend on VOI-SHAN for prompt delivery and unquestioned quality.

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A division of PHEOLL MANUFACTURING COMPANY
8463 Higuera St., Culver City, California

Offices in principal cities of the United States and Canada

For information on possible applications of super alloys to your fastener problems, consult with VOI-SHAN field engineers, or write for complete catalog.

by Carl F. Joseph
Technical Director

CENTRAL FOUNDRY DIVISION
GENERAL MOTORS
CORPORATION

.....The metallurgy of strength and

The secret of a stronger iron casting lies in the composition, the melting and the heat-treating processes. Perhaps I should use some other word than "secret," because the fact is well known today, but in 1925, when we started our search for a stronger iron, the principle was well known only in respect to steel.

Our research led us to think that heat-treating could improve iron as well. After considerable experimentation, we learned how to arrest the malleablizing process to produce an improved pearlitic malleable iron . . . an iron that compares favorably with the properties of a good grade forged steel. It is from the words "Arrested Malleable iron with Steel-like characteristics" that the name "ArmaSteel" was coined.

The raw materials and melting process for ArmaSteel are very similar to those of our malleable iron . . . the major difference being in the heat-treat cycle. In the cupola, we melt steel scrap, ferrosilicon, and remelt. We add .0025% boron to the charge to assist in breaking down carbides during malleablizing.

Next, the molten iron is tapped into a forehearth where it is desulphurized with soda ash. This removes small particles of slag and impurities, thus improving machinability of the casting. After refining in an electric furnace, the iron is tapped into ladles.

To improve the physical properties on certain castings, .007% bismuth is added as a ladle inoculant: this stabilizes the carbides during the initial freezing of the metal. On heavy castings such as the Pontiac crankshaft, up to .02% bismuth is added. This bismuth-boron combination is a new development.

I mentioned before that the heat-treating of ArmaSteel greatly affected its properties. Actually, we use several different heat-treatments to produce the several ranges of ArmaSteel. All are alike during the malleablizing cycle, where the massive carbides are eliminated. Malleablizing requires about 20 hours: the castings are held at 1750°F. for 10 hours, and near the end of the cycle are dropped to 1650°F., after which they are air-quenched. Brinell hardness at this point is around 300.

Tempering brings the Brinell hardness down to customer's specifications. We produce two standard Brinell ranges of air-quenched and tempered ArmaSteel . . . BHN 197 to 241 (3.9-4.3 mm.), and 163 to 207 (4.2-4.7 mm.). The castings are tempered in a recirculating furnace. The harder material is in the furnace for a total of six hours and forty minutes, and is held at heat for three and one half to four hours at 1270° to 1290°F. The softer material uses the same time cycle but higher heat . . . from 1320° to 1340°F.

For automobile crankshafts, a special hardness range is used. The ArmaSteel is air-quenched and tempered, but the tempering is for six hours at 1200°F., which produces a harder material (BHN 217 to 269).

Two other types of ArmaSteel are produced by reheating the air-quenched castings to 1600°, holding at heat for thirty minutes, then oil-quenching. These are then tempered for three and one half hours at 1170° to 1190°F. BHN is 241 to 260 (3.7-3.9 mm.) and 269 to 302 (3.5-3.7 mm.).

I've gone into detail on heat-treating because it has such a great effect on mechanical properties. Tempering directly controls the amount of combined carbon in the matrix, and this in turn dictates how hard and strong the ArmaSteel will be . . . the higher the combined carbon, the stronger, harder, and less ductile the casting. Thus, the engineer can choose the combination of properties best suited to his application. I can best explain the results of this careful heat-treatment by giving you a brief list of the mechanical properties of ArmaSteel.

1. *Machinability* . . . Because of the carbon nodules in the pearlite matrix, the machinability of ArmaSteel is generally from 10 to 30 percent better than that of steel forgings of the same Brinell. Improvements of up to ten times longer tool life and three times more pieces per machine have been shown.

2. *Selective Hardening* . . . ArmaSteel responds readily to localized hardening, either by flame or induction methods. A minimum of Rockwell "C" 50 is obtainable on such parts as shifter yokes, rocker arms, and gears. Some applications use the lead immersion or hot salt bath methods, followed by an oil-quench.

3. *Bearing Properties* . . . ArmaSteel is such an efficient bearing material on a hardened steel shaft that bronze bushings are often eliminated. The automotive rocker arm illustrates this excellent non-seizing property in metal-to-metal wear.

4. *High Yield Ratio* . . . The oil-quenched and tempered ArmaSteel has a minimum yield strength of 80,000 psi and ultimate strength of 100,000 psi, making it ideal for highly stressed parts.

5. *Fine Machine Finish* . . . A mirror-like finish can be produced on ArmaSteel. Diesel pistons are an application where this fine finish reduces friction wear to a minimum.

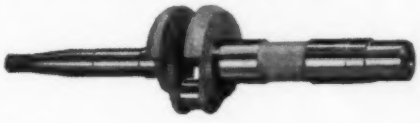
6. *Damping Characteristics* . . . In both small engines and in automotive engines, ArmaSteel crankshafts exhibit a fine damping capacity that aids quiet operation.

7. *Wear Resistance* . . . ArmaSteel withstands excessive wear under heavy loads at high speed.

8. *Fatigue Life* . . . ArmaSteel has good resistance to fatigue, giving maximum endurance and long life.

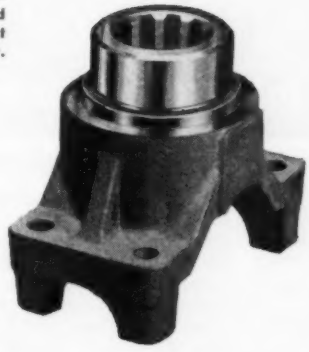
As countless and varied applications have proven, ArmaSteel is an outstanding engineering material. For information on how your product can benefit from this modern casting metal, write for our "ArmaSteel" catalog.

ARMASTEEL® from the standpoint of machinability

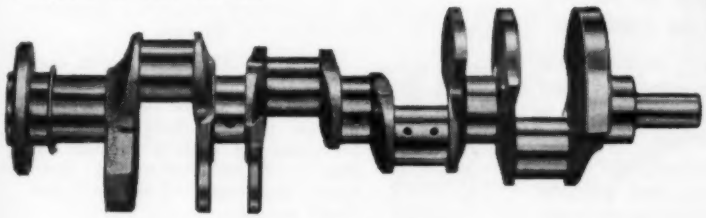


ArmaSteel small horsepower engine crankshafts provide good damping qualities and modest cost due to excellent machinability.

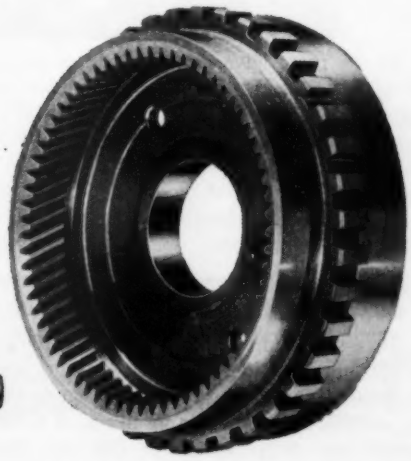
ArmaSteel's adaptability to localized hardening pays off especially well on these automotive rocker arms.



Universal joint yokes of ArmaSteel stand up under severe stresses to same extent as former SAE 1145 or 1151 forgings.



Pontiac's conversion to ArmaSteel Crankshafts doubled cutter life and speeded up by 50% the grinding of main journals.



Because of its excellent wear resistance, oil-quenched and tempered ArmaSteel with a Brinell of 241 to 269 has replaced an SAE steel forging for this automotive reverse internal gear.

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Circle 546 on page 19

XUM

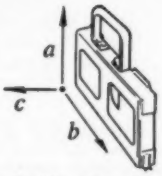
Starfighters' Fire-control Radars Use Barry's NEW Integral* Mounting Systems

In the most advanced airplane of its type ever developed — Lockheed's F-104A Starfighter — Barry's new Integral* Mounting Systems are solving the toughest combination of shock, vibration, and sustained-acceleration problems ever posed by jet aircraft. Literally a "missile with a man in it", the F-104A demands that equipment mounts give superior performance, in less space, and at lighter weight than ever before.

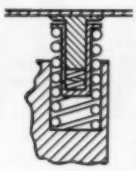
Here's how Barry's Integral* Mounting Systems are meeting this demand in the production models of the Starfighter.

In a space only 12¾ x 5⅜ x 1-13/32" on each side of a 150-pound load . . . a pair of units weighing less than three pounds each . . . provides adequate vibration isolation at 4g sustained acceleration in all radial directions . . . passes all shock-test requirements of this supersonic fighter . . . performs reliably through wide temperature and altitude ranges . . . and provides positive, quick-release attachment to the airframe to satisfy Lockheed's requirements for "plug-in" electronics-system components.

Here's the way this system works.



Helical springs designed to function in their axial direction only are grouped about the load attachment points so as to provide controlled resistance to movement along the *a* and *b* axes. For the *c* axis, resistance is provided by the slightly tapered side flanges of the mounting frame working against the displacement of all the load-carrying springs.



Damping adjustments (see diagram), completely independent of the stiffness of the load-carrying springs, provide design flexibility for obtaining desired natural frequency, transmissibility at resonance, and degree of vibration and shock isolation.

Write for THO-5 containing a full exposition of this All-Angl Integral* Mounting System.

BARRY CONTROLS
INCORPORATED

BARRY B MOUNT

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

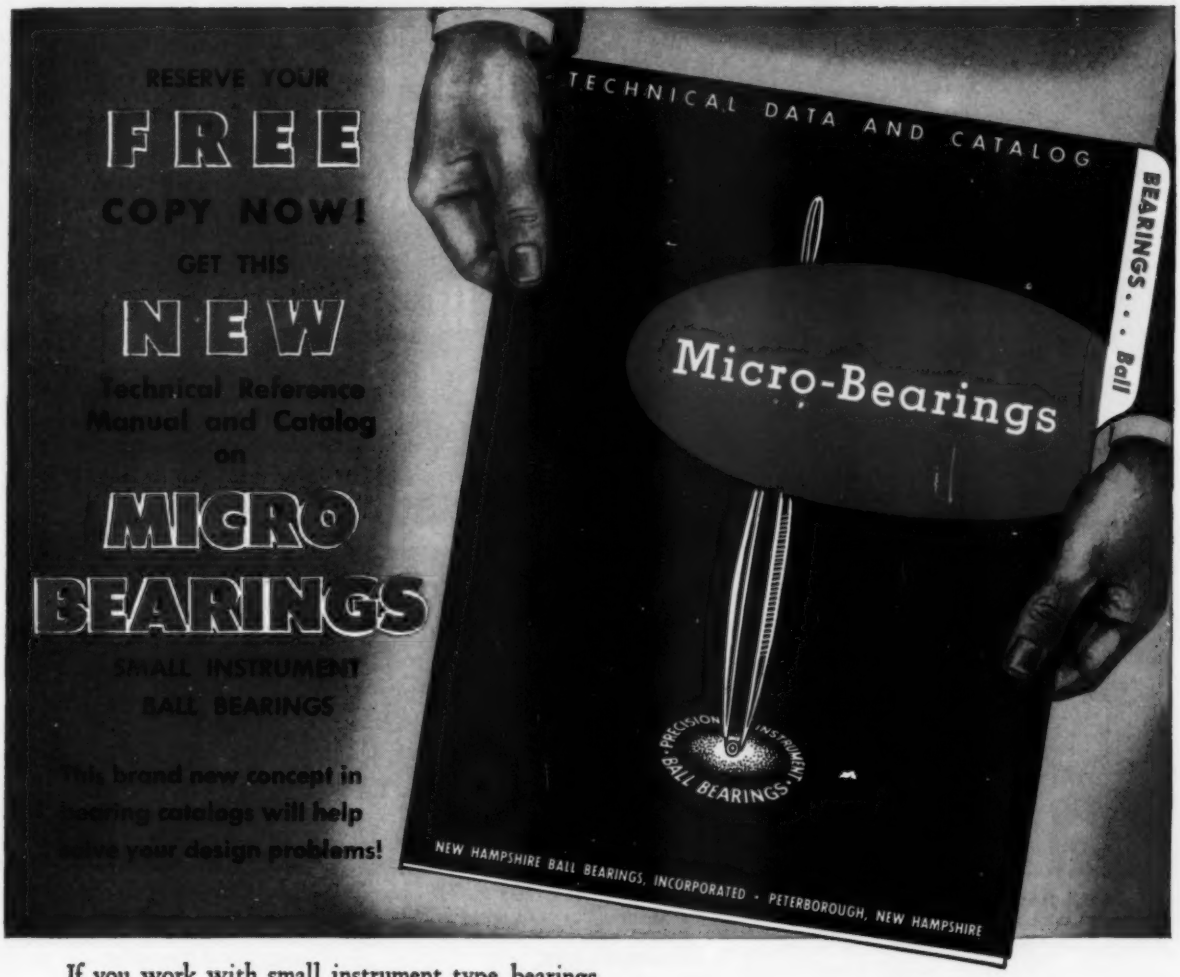
722 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS

Integral means . . .

Designed specifically for the environment performance requirements.

Built specifically for the equipment.

You can save time, space, and trouble by bringing your shock and vibration problems to us. Call your Barry sales representative.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NEW HAMPSHIRE BALL BEARINGS, INCORPORATED • PETERBOROUGH, NEW HAMPSHIRE

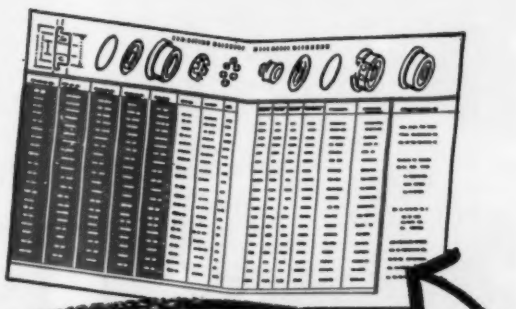
If you work with small instrument type bearings you'll find this new, authoritative publication an extremely valuable and handy source of engineering data arranged in convenient form for practical reference.

LOOK AT THESE FEATURES . . .

- A helpful survey article: "FACTORS TO CONSIDER IN SELECTING SMALL INSTRUMENT BALL BEARINGS."
- A complete, practical presentation of bearing facts:

Types of bearings	*Dynamic and static loads*
Materials	*Lubrication*
Components	*Radial and Axial play*
Engineering standards	*Torque*
Tolerances	*Mounting practice etc.*

- Large, clear illustrations.
- Big, easy to follow charts.
- Convenient nomographs and conversion charts.
- Simple bearing designations make ordering easy.



WRITE TODAY . . . GET YOUR NAME ON OUR PRIME DISTRIBUTION LIST FOR MAILING

NEW HAMPSHIRE BALL BEARINGS, INC., *Peterborough, New Hampshire*

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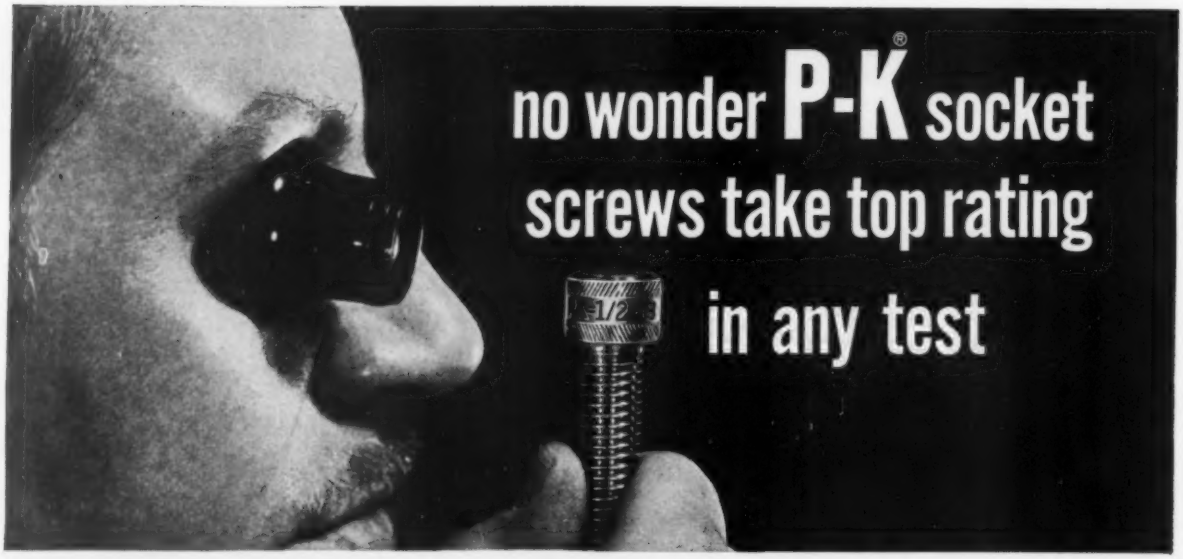


no wonder P-K® socket screws take top rating in any test

ROCKWELL HARDNESS TEST. With this familiar laboratory device, the hardness of screws is carefully tested as a check on heat-treatment.

PERFORMANCE. Both the raw material and finished screws are tested on this equipment to determine ductility and strength under tension loads.

HEX DIMENSIONS. To make sure that the hex meets exacting specifications, a team of inspectors check dimensions across flats at the machine.

HEAD DIAMETERS. As heads are shaved on automatic machines, such as those shown here, constant checking by operator and inspector maintains accuracy.

THREAD CONTOUR AND LEAD. The Comparator permits checking of thread contour and lead of screw heads against Class 3A Tolerances.

SEE FOR YOURSELF

These are just a few of the steps in the rigorous test and inspection routine conducted in Parker-Kalon's modern fastener plant. Exacting quality control assures that all "doubtful screws" are eliminated—that every P-K Socket Screw delivered to you is first quality. Parker-Kalon guarantees that it's first quality. In strength, dimensional accuracy and overall uniformity, you can be sure . . . "if it's P-K, it's O.K."

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

PARKER-KALON® fasteners

Sold Everywhere Through Leading Industrial Distributors
Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

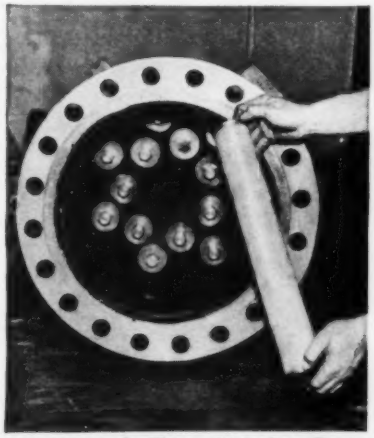
(Advertisement)

Tips on Selecting a Filter

Most filter needs fall into one of two categories that we can conveniently call product filters or functional filters. Occasionally, a combination of both is required.

Product Filters

A product filter—as suggested by the name—removes any particles that impair product quality or hurt sales appeal. Such particles can be captured and measured. Their size indicates the necessary degree of filtration. A good rule of thumb for selecting filter size here is: Select a standard filter spacing next smaller than the objectionable particle. In some cases, a safety factor may be obtained, at slight additional cost, by selecting the second smaller spacing.



FILTER FOR 400°F. This multiple Cuno PORO-KLEAN filter unit provides 3-30 micron filtration of 180 gpm of naphtha at 700 psi. It's typical of the wide range of filter problems tackled by Cuno engineers.

Functional Filters

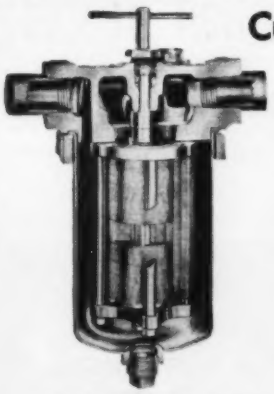
A good example of a functional filter is a unit installed to protect an orifice, nozzle, or similar part. Here, it's good practice to select a degree of filtration of approximately half the size of the aperture to be protected. However, the nature and number of contaminant particles will sometimes vary this choice. A drastic reduction in the degree of filtration may be called for by contaminants which agglomerate, or which might wedge into circular orifices, or which enter in very small sizes and settle to build up sludge at slow moving spots in a system. Selection of a filter for these applications is affected by the nature and cost of the unit it is to protect. In many cases, its price can be regarded as an insurance premium on the life or reliability of the system which it protects.

Combination Filters

A good example of the combination product and functional filter is one used in a rolling mill to prevent roller damage and finish scouring by particles in coolant. Here, it's the metal finish desired that determines to what degree the coolant is filtered. If final finish is unimportant, only large particles of dirt (say from 0.035" and up) need be removed. On the other hand, for fine 0.0015" aluminum foil you need a much finer filter to avoid damage to rolls or scouring. A micronic filter—such as Cuno's MICRO-KLEAN—is indicated here.

If you have filtration problems like these, your Cuno representative will be glad to help you work out the solution. Or write to The Cuno Engineering Corporation, 14-11 South Vine Street, Meriden, Conn. 61

Cuno case study capsule



Cuno's SUPER Auto-Klean

PROBLEM:

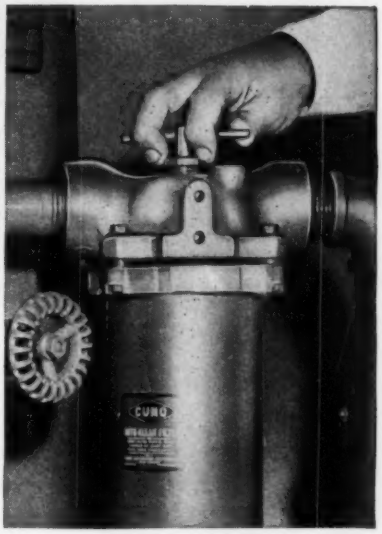
40 micron filtration of 35 to 45 gpm of SAE 20 or 30 lube oil for 6 and 8 cylinder diesel engines. Temperature 180° to 220°F.

SOLUTION:

Cuno's SUPER Auto-Klean. Manager of research stated that SUPER Auto-Klean removed at least 10 times as much dirt as their by-pass screens! And with no interruption to service for cleaning!

Another example of the wide application range of Cuno filters.

FILTRATION NEWS



Filter to 40 microns, turn handle to clean!

You can clean this 40-micron filter simply by turning the handle at intervals—or turn shaft continuously with motor drive.

It's Cuno's SUPER Auto-Klean—using a completely new principle in metal edge-type filtration.

For compact, economical engine fuel and lube, machine-tool coolant and cutting oils, and a wide variety of process fluids, SUPER Auto-Klean offers:

Complete protection against solid particles larger than 40 microns—actually 0.0015". Can't rupture or channel.

No cartridge changes—just turn handle frequently to clean and, at intervals, remove plug and drain sump.

Low pressure drop—3 psi drop with flow rate to 45 gpm for 8" long by 2¼" diameter cartridge and fluid of 200 SSU viscosity.

All metal construction—available in stainless steel for corrosion-resistance.

Standard housings—available with Cuno's standard AUTO-KLEAN housing; available also for integral sump mounting.

Write today for complete data on this outstanding Cuno filter development. Ask for Catalog SAK-057. The Cuno Engineering Corporation, 14-11 South Vine Street, Meriden, Conn.

63

CUNO ENGINEERED FILTRATION

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

Circle 550 on page 19

XUM

American Tool Works Co.
smooth operator...
A hole is a hole is a hole—but American Tool's 32-speed Hole Wizard Radial Drill makes them with the speed and consistent accuracy that precision production demands. And Federal XLS Ball Bearings keep the vertical shifting mechanism functioning smoothly.
tough customer...
The powerful impact action of this Chicago Pneumatic Wrench makes child's play out of tightening and loosening the huskiest nuts and bolts. It pounds away from day to day with no sign of fatigue. Here, too, Federal Ball Bearings can "take it".
Chicago Pneumatic

so much of industry *turns* on FEDERAL ball bearings

Dependability is a proud word, especially when you apply it to machines. And wherever you find dependable machines—in home, office or factory—you're almost sure to find Federal Ball Bearings making their vital contribution toward smooth, trouble-free performance. 12,000 sizes to solve your anti-friction problems. Hundreds of types. Produced by a 50-year-old manufacturer of ball bearings exclusively.

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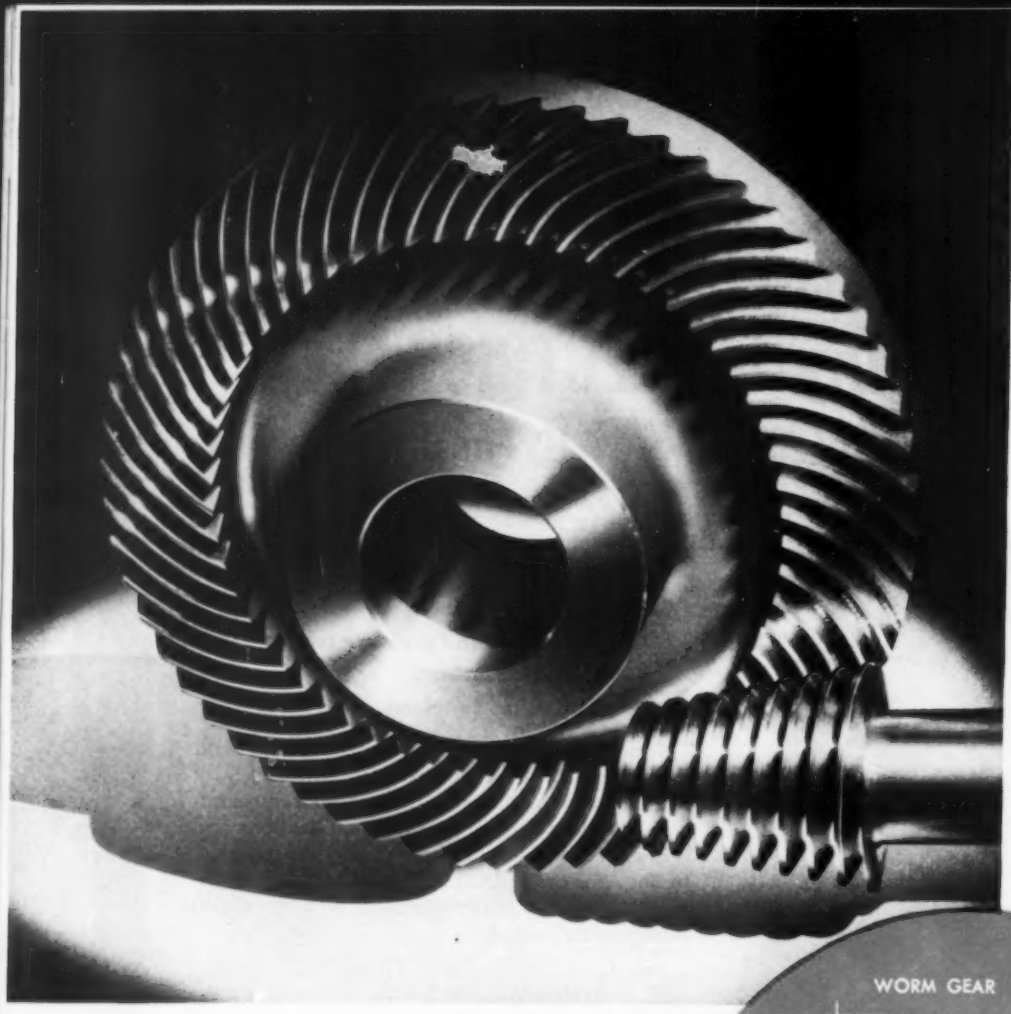

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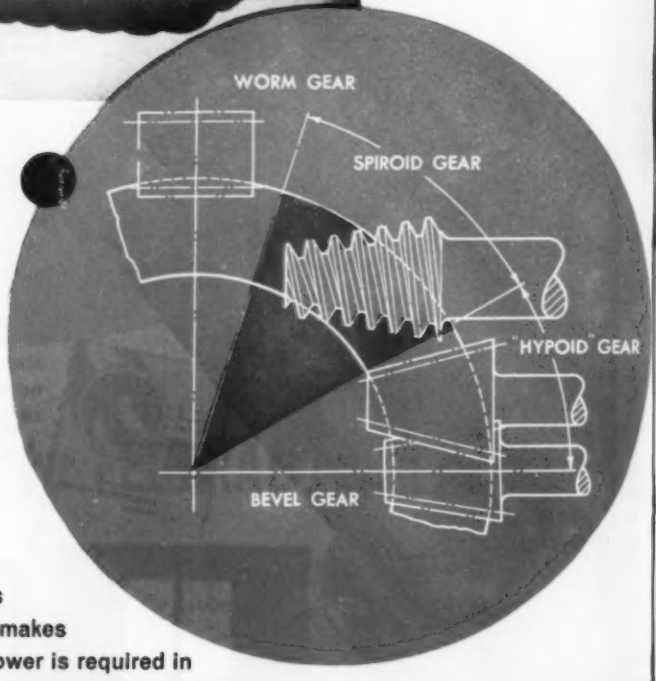

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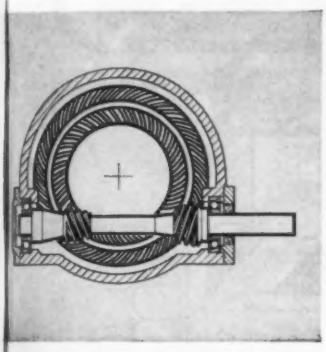

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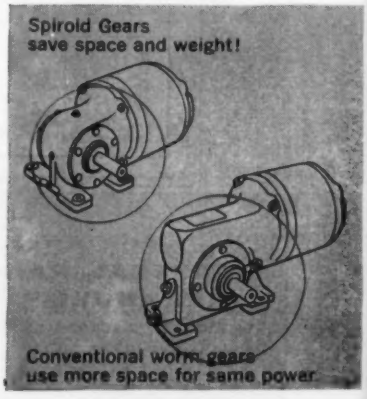

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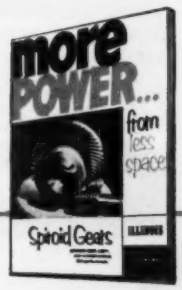

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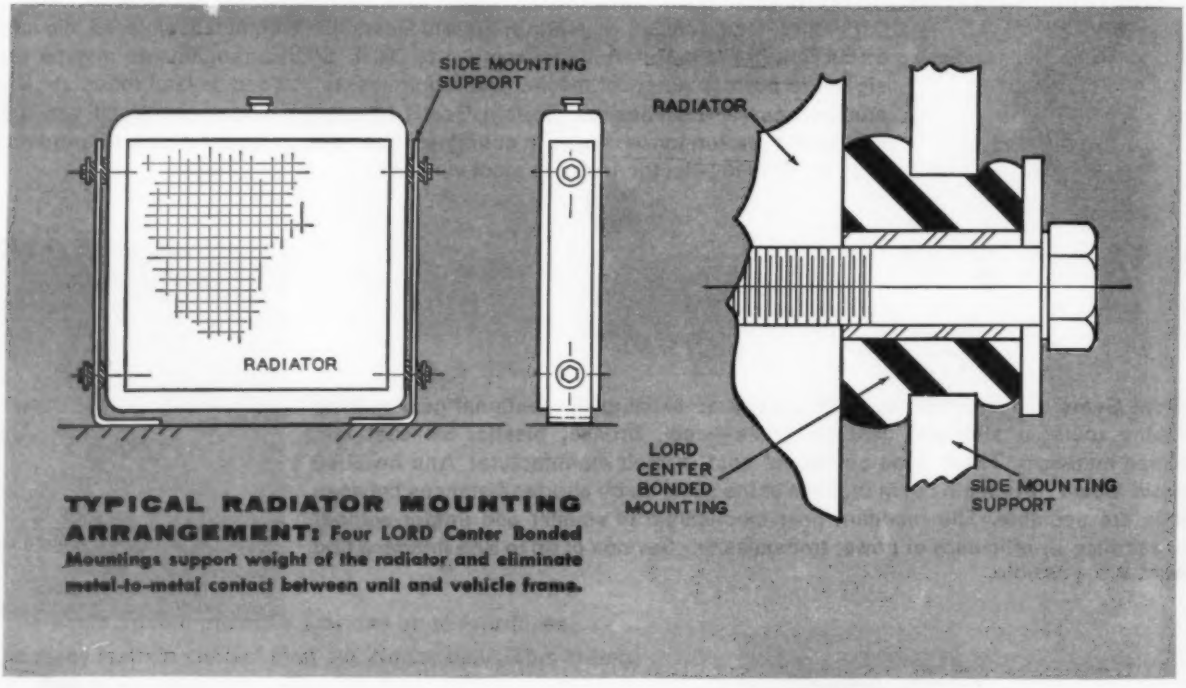

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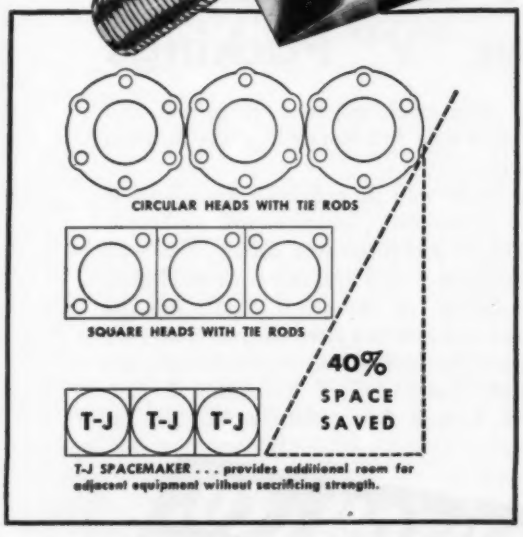

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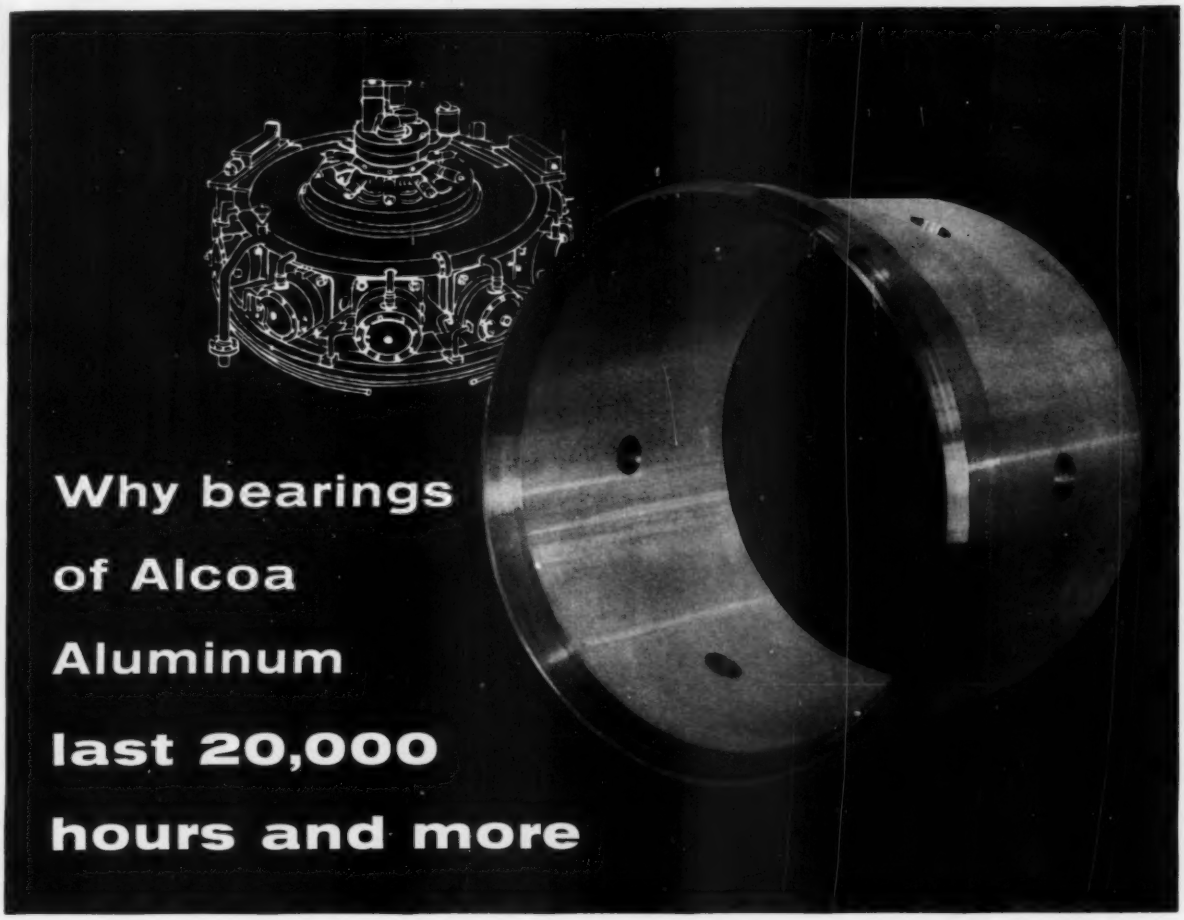

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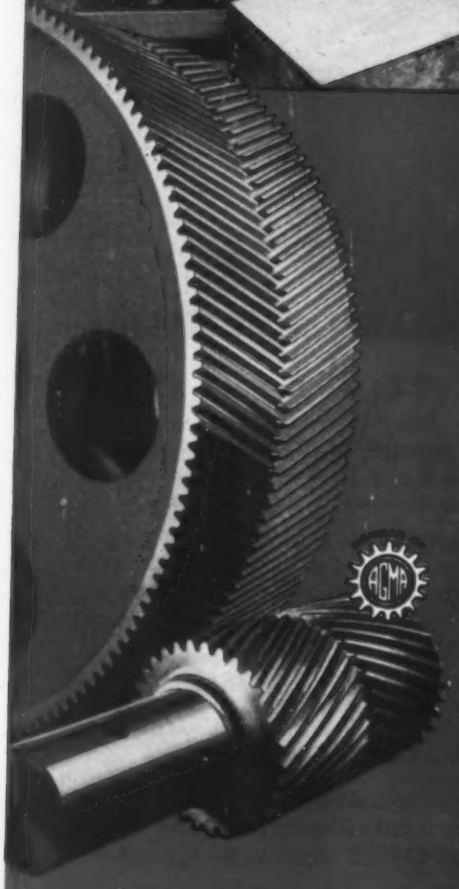

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MACHINE DESIGN
NOVEMBER 15, 1956

Joining Forces

TODAY the engineer is king—or should be. Public appreciation of his role in creating our standard of living and insuring our national safety has never been keener. High demand for his services has given the engineer an unprecedented feeling of economic security, and salaries are rising.

Yet many an engineer who "never had it so good" seems restless and dissatisfied. Among factors contributing to this unhappy state is an apparent lack of faith in the effectiveness of his company's management, according to at least one recent survey.

Engineers accustomed to working with facts and basing decisions on the most complete available data have little sympathy with the management type who, to get things done, must often decide questions on meager information.

Management, on the other hand, is often impatient with engineers who seem so fussy about details. Perhaps management decisions are often made without the engineers' advice being sought simply because of unwillingness to listen to all the pros and cons which the fact-minded engineer deems important.

Communication lines need to be opened up. Among the techniques that can be used to get management people and engineers better acquainted with each other's viewpoints is the job-performance interview discussed in Bud Covner's article beginning overleaf.

Management using this technique for the first time should be prepared for some shocking evidence of the low esteem in which it is often held. But frank discussion and mutual desire for understanding can restore confidence. In the proper atmosphere the respective talents of engineers and executives can complement each other and join forces for more effective action.

Colin Carmichael

EDITOR

Does every engineering department employee know "where he stands" on job performance, personal status, and future opportunities?

Are all working relationships in the department satisfactory and without friction?

An unqualified "yes" answer to all of these questions would be most unusual; every organization has a certain number of "people problems" —at employee, supervisory and management levels.

The procedure suggested in this article is one way of helping to answer these questions. It recognizes people as people—not as numbers on a time-clock card or cogs in an industrial machine.

In short, it stresses the most critical element in any group of people working together—good human relations, attained through the use of . . .

JOB-

. . . *principles,*

AN ENGINEER says, "I've been with this company for five years, and I haven't had a single person tell me how they liked my work, or what they view my future opportunities here to be."

In another company, a much harried personnel manager laments: "We have just lost one of our more promising engineers. We looked into the matter and found he liked our company very much, but felt that no one was particularly interested in his progress and plans for further development. So, another company across town made a pass at him. He's starting with them next week, and it's already too late for us to stop the move. It will take his replacement quite some time before he can even be useful, let alone do the job well—if and when we get a replacement."

These typical examples illustrate both a problem and an opportunity in the development and utilization of employee and managerial personnel—a problem in the sense of being a common friction point in practically all engineering organizations; and an opportunity in the sense that proper "oiling" of this friction point may result in improved organizational effectiveness.

The suggested procedure for taking care of this situation is the post-appraisal interview. In plain English it is a chat with a person about his job performance. Chronologically it takes up where appraisal as such[1] leaves off. Three aspects of job-performance interviewing will be discussed: the need, factors that affect application, and a method.

Why Job-Performance Interviewing?

One reason is to take full advantage of proper organizational functioning. Why do organizations exist in the first place? Certain tasks can't be performed by a single person; instead, a group of people is required. On the other hand, certain people are unable to satisfy their needs on their own; they require affiliation with an organization. Thus there are both *company* and *individual* needs to be fulfilled.

While this seems most elementary, for an organization to run smoothly there must be proper *fusion* of company and individual needs. It is all too easy for them to conflict. This fusion is best accomplished when the company and the individual are well informed concerning the other's needs. The periodic interview is well suited for this purpose because it enables both company and individual needs, which change in strength and content from time to time, to be communicated.

This action permits *two-way* development. Both parties are able to diagnose current difficulties and plan next steps more effectively when they are informed regarding the other's needs. Viewed in

[1]References are tabulated at end of article.

Is every engineer and draftsman working at his best performance level?

Is communication between engineering management, supervisors, engineers and draftsmen on a free, informative basis?

By Bernard J. Covner
Assistant Vice President
Dunlap and Associates Inc.
Stamford, Conn.

PERFORMANCE INTERVIEWS

methods, and practice

this light, the post-appraisal interview becomes a means of obtaining improved performance at *all* organizational levels. Contrast this view with the more conventional one in which post-appraisal interviews are seen as a means of a superior's "straightening out" a subordinate.

A second reason for job-performance interviewing is to use sound principles of learning and motivation. Performance is *not* just a matter of ability and practice. Knowledge of results is necessary for a person to improve his performance. How this information relates to a person's needs will influence his performance considerably.

In working with supervisory personnel ranging from group leader or supervisor to president, the author has acquired hundreds of "signed confessions"—written descriptions of instances in which a supervisor deliberately avoided responsibility or went out of his way to give someone else, usually his superior, a rough time. The explanation for this mass sabotage is frustration of some need of importance to the person in question—fair treatment, security, and so on.

All sources of need-frustration considered, frustration of a person's need for recognition outnumbers all other frustrations combined in a ratio of approximately 2½ to 1. The typical example reads about as follows, "I went out of my way to clear up a difficult situation, got wonderful results such as improved quality and productivity, and never got so much as a thank you. I was plenty burned up, and for quite a while thereafter did as little as I could get away with."

Every person needs recognition. But there is evidence that the higher a person's position, or the higher his level of aspiration, the more important it is to satisfy his need for recognition. Popular views to the contrary, salary increments, promotions, and even a tremendous amount of freedom do not automatically satisfy the need. People like to be told personally, and this of course illustrates the need for a personal discussion.

Human learning and motivation are much too complicated to be reduced to a single, simple formula. On the other hand, certain actions tend to give certain results with remarkable consistency. Fig. 1 illustrates some of the variables and the relationship between them. It says, in effect, that use of praise and reproof makes for faster learning than not letting people know how well they are doing. Periodic praise during learning may result, for example, in productivity increases of 70 per cent or more. Failure to communicate performance

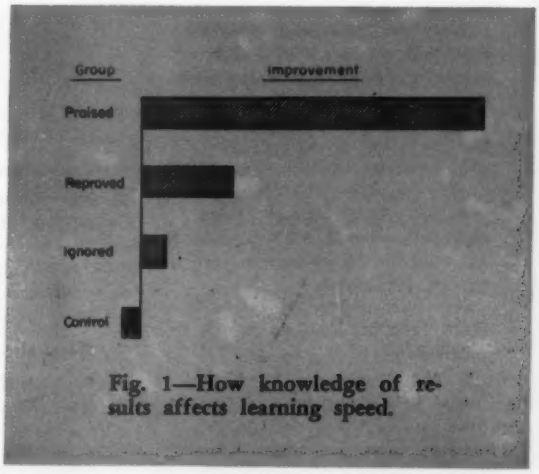

Fig. 1—How knowledge of results affects learning speed.

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status, on the other hand, may even result in lowered productivity. Fig. 1 also confirms the validity of the time-honored practice of commenting on performance only when something goes wrong (reproof) but shows that combining this method with praise has potential for considerably greater improvement.

A third reason, to sustain *good* performance, is essentially an extension of the second. Fig. 2 represents what frequently, if not typically, happens in the course of a person's affiliation with an organization. He may start off well, but after a while his performance drops off somewhat. In some instances his performance may stay at a fairly satisfactory level, but his attitudes toward the job or the company may become sour. When his performance, or attitudes, or both reach a low point, one of three things happen, generally speaking. Finding out where he stands, and having a discussion about future plans may result in a return to high-level, enthusiastic performance. But if there is no such knowledge of results, he may continue at a mediocre level or—as so frequently happens among engineers these days—he may quit and join a competitor.

The analogy between this aspect of human behavior and machine maintenance is obvious. Like machine maintenance, the need for knowledge of personal status is constant. Just one chat about performance is hardly adequate. The procedure should be repeated from time to time—say at six-month or yearly intervals. Interestingly, virtually every managerial group claims more difficulty with "established, experienced" people than with new ones."

Factors that Affect Its Use

Management literature abounds with articles on methods and values of post-appraisal or job-performance interviewing, yet the practice is not proportional to the publicity. "Theoretically it's a fine idea, but how do you get people to do it" is a common saying. Such a remark, incidentally, occurs even in companies that have formal procedures for appraising performance. Here is what one specialist said about the problem after conducting workshops on executive communication:

> For most executives, the kind of communication that presents the greatest difficulty—the one they shy away from and often postpone indefinitely—is the appraisal interview. Executives find it difficult and embarrassing to criticize a subordinate's work. Despite their "strong man" reputation in

Table 1—Steps in a Job-Performance Interview

1. Prepare for the interview

Be in a congenial frame of mind. Try to interview when the other person is in a congenial frame of mind. Have necessary materials available — records, notes, completed forms, etc.

Make the necessary physical arrangements — the interview should be held in a place where privacy is assured. Even telephone calls can break up a crucial line of thought.

Make certain that you have all pertinent facts.

Try to anticipate questions that may come up in the interview. Determine, if possible, what the answers are. Keep in mind that in certain instances it is best for the other person to provide the answers, which frequently might be different from what you had thought them to be. If necessary, check with superiors on matters of company policy, special procedure, etc.

Arrange your schedule to eliminate interruptions as much as possible.

2. Put at ease

Try to put the other person at ease at the beginning of the interview. This will not be difficult in cases where a close relationship already has been established between two people.

Some of the things which help to put a person at ease are: a friendly and sincere manner; a comfortable tempo, not too slow, not too fast; a courteous manner; and privacy.

3. Explain purpose

Although every person will probably have some information about these interviews, there will be various interpretations of their purpose. First determine what the interviewee's understanding is, and then provide additional information as necessary.

4. Give chance to react

5. Give overall appraisal

Examples of overall appraisal are: "on the whole your work is quite satisfactory" or "we find your performance to be excellent."

6. Give chance to react

7. Present positive aspects of performance

8. Give chance to react

9. Present aspects of performance most in need of improvement

10. Give chance to react

11. Solicit improvement suggestions

There are several ways of approaching the question of improvement and much depends upon the interviewee's aspirations. First give the interviewee an opportunity to make suggestions. If he offers none, ask him if he has any ideas concerning improvement. If he still makes no suggestions, make suggestions in the form of questions, such as, "do you think it would help to . . . . . .?", etc.

12. Develop a plan for improvement

13. Stimulate further discussion if necessary

14. Follow up; look for progress and compliment where pertinent; otherwise, analyze further

general, they are decidedly shy when it comes to making a frank statement to someone else about his shortcomings.[2]

This state of affairs suggests measuring the depth of the water before diving in. Many supervisors unquestionably dodge their responsibility for letting people know where they stand, but it is a mistake to beat them over the head and expect them to do otherwise without studying *and* altering the conditions that impel them to act this way. One or more of the following factors make it difficult for a manager to discuss a subordinate's performance with him:

1. He doesn't know enough about his own job or the subordinate's job to talk to the latter with confidence. He thinks, wrongly, that he has to have all the answers before he can stimulate others to improve.
2. Even though his job description says so, he may not realize that he has a responsibility for post-appraisal interviewing.
3. He may be unfamiliar with the needs for and values of talking with a person about his performance.
4. He may lack skill in interviewing techniques.
5. He may be so disturbed by "environmental" factors—unsatisfactory relationship with superiors, overloaded by amount of work or being improperly qualified for his job, being a manager in name only, being underpaid, etc., that his effectiveness as an adviser and coplanner is limited.

This set of factors that impede application of post-appraisal interviewing is indeed a formidable one. It is all too easy to examine it, heave a sigh, and say, "Oh well, what's the use!" It suggests that there is a dilemma here, and that whatever method or approach will break the dilemma must have the characteristics of a "bootstrap" technique. Does such a bootstrap technique exists?

An Interview Method

There is probably no single, sure-fire answer to the problem. But there is an approach with several desirable features not found in earlier, more conventional methods. It gives excellent results in the relatively uncomplicated case where background factors are favorable. And it helps break the ice in situations where poor manager-superior relationships or other negative factors exist. One of its key features is the use of both interviewing and supplementary managerial techniques for discovering and constructively handling negative factors.

Interviewing Techniques: The understanding and acceptance of points made by either party in an interview are influenced considerably by personality factors. Often the issue is not the points themselves, such as "exceeds budgets" or "disregards production deadlines," but how they are perceived and reacted to.

Level of Aspiration: Perceptions of and reactions to points made in an interview are affected by a person's desires, technically called his "level of

Table 2—Methods for Improving Communication

Listen—Pause

Attend actively to what the other person is saying, and, in many instances, interpret what he is *trying* to say or really means. This is not just halting your own flow of words to give the other fellow a chance to talk. A good test of ability to listen is to be able to summarize what the other person has just said. For many people this skill is extremely difficult to acquire.

Response to Feeling

Show awareness by your own statements of what feelings the other person is expressing. "Apparently you're pretty mad about what happened," and "you're pleased about that development" are typical examples of response to feeling. Use of this technique helps greatly to draw people out, make them feel noticed, and helps return them to a more "objective" state of mind. A few people seem to use it naturally; most people are completely ignorant of it and tend to ride over the other person's feelings with roughshod logic. The result is usually that the situation becomes even more emotional.

Turnback

This technique helps in handling "loaded" questions. Its use helps to find out what is really behind the question. If the question is really straightforward and merely seems loaded, the turnback gives more time to think. Suppose that someone asks "How does my work compare with Charlie's?" The answer, "what are your thoughts on that" is an answer that exemplifies turnback. Typically the other party will proceed to answer his own question. If he still presses for an answer, at least there has been more time to prepare an answer. It's usually alright to answer the question to the best of one's ability. The turnback has a very important additional use in getting people to think for themselves and, as a result, present excellent original ideas.

Elaborator

The elaborator is a simple device for getting more information before expressing one's own views, and acts as a self-check in preventing sounding off prematurely. It consists of asking for reasons or otherwise encouraging a person to tell more.

Noncommittal Filler

This is a polite, effective way of telling the other party that you are alive, awake, and still listening with interest—without agreeing or disagreeing with what he is saying.

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aspiration." Thus, his ability to understand and accept statements of the other person—particularly those about his performance—depends upon whether he aspires "just to get by," "to do as well as most," "to be the best man in the group," and so on.

For instance, in one company an engineer received an "outstanding" performance rating. Upon learning that many of his associates received similar ratings, he became disgruntled, saying that his rating wasn't high enough to satisfy him, and that it implied his being "no better than the next guy." From this time on he became increasingly critical of the company's management.

Concept of Self: A closely related personality characteristic is the picture one develops over an extended period about the kind of person he is, technically his "self concept." To take a few common and somewhat oversimplified examples, a person may see himself as a leader, a mechanical genius, God's gift to women, a doer, an average "Joe," someone who won't be pushed around, and the like. People tend to react negatively to experiences which are inconsistent with or threaten their self concept. For example, the person with a good credit record and a reputation for paying bills promptly hits the ceiling when a department store's clerical error results in his being billed repeatedly for something he has already paid for.

Resistance and Defensiveness: There is a close connection between how a person accepts unfavorable comments from others and how well he gets along with others and adjusts to life generally. Resistance and defensiveness are characteristic of maladjustment. Stony silence or violent counterarguments are common examples of this type of behavior.

These overlapping characteristics—level of aspiration, self concept, resistance and defensiveness—apply to *both* parties in face-to-face inter-personal situations such as interviews. Each must attend carefully and patiently to what the other says. As either party deviates from this requirement the other will tend to "clam up" or argue, thereby stopping or hindering constructive action.

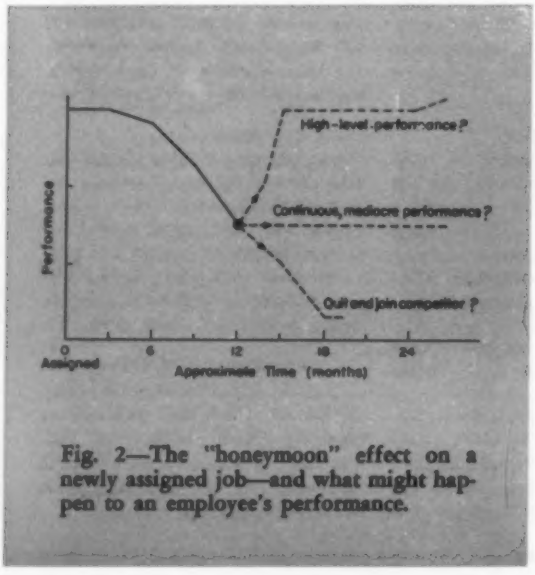

Fig. 2—The "honeymoon" effect on a newly assigned job—and what might happen to an employee's performance.

This very brief description of personality factors that influence the effectiveness of communication between two people suggests the importance of looking at interviewing techniques as more than a matter of asking questions and giving answers. Successful interviewing calls for techniques that function as communication gateways rather than barriers.

Two sets of techniques meet this qualification. One, a general procedure, is widely applicable to situations in which it is desirable to sustain adequate performance. It is described in Table 1.

The steps in Table 1 cannot and need not always be followed in the exact order listed. If the interviewee takes the lead or wants to talk about a particular problem, the interviewer need not be bound by the suggested steps. It is more essential to be a good listener at all times and allow discussion of what is important to the other person at the time. In general, however, the suggested order should be followed fairly closely.

The second set of procedures, summarized in Table 2, act in a sense as catalysts for the first. They help to prevent communication blockages from developing in an interview, and are helpful in eliminating them when they do occur.

Supplementary Managerial Techniques: Suppose that a manager has learned how to interview his subordinates periodically about their performance. Two questions arise immediately: (1) why must he wait six months or a year to discuss some aspect of performance, and (2) isn't there the chance that his daily behavior will be inconsistent with his semiannual interviewing behavior?

Both of these questions imply that there is need not for just a special period mode of behavior but for a daily mode, and that whatever good is done periodically can be canceled between interviews. This is where a supplementary technique comes in. The method described here helps develop managerial skills that have daily as well as semiannual application, by helping to develop *managers* rather than just occasional interviewers.

How is this accomplished? Table 3 outlines a series of weekly sessions. These sessions—usually 2 hours long—are designed to be a miniaturized procedure for developing manager effectiveness. What the sessions do, essentially, is to sensitize people to various needs—those of the company, people in general, and themselves—and then equip them with skills that help satisfy these needs in their daily performance as managers.

In these sessions, considerable emphasis must be placed on the *prevention* of problems both through sensitizing group members to needs and providing them with problem prevention skills. Also, there must be consistency between the methods used to prevent problems, and those used to handle problems that develop. This consistency

of method and viewpoint helps the individual manager develop a single set of "managerial clothes" that he can wear every working day, thereby eliminating, in a sense, the necessity for a different approach for every problem that comes along. The program must also be integrated with a manager's own job at the time the program gets underway.

This point can be made clearer by discussion of the teaching methods which can be used. These methods can be summarized as:

1. Assignments
2. Experiments
3. Demonstrations
4. Role playing
5. Success reports
6. Illustrated lectures
7. Case and film discussions

Note, first of all, that *several* methods are used. Also notice the combined use of very old methods, such as assignments and lectures, with newer methods such as case discussions and role playing (acting). The assignments force participants to think actively and practically about the application of the program's topics to problems that exist in their own departments.

Results

Two types of results are generally noticed. The first is attitude modification. It is characteristic to obtain changes in a person's understanding of himself, others, and of his company that influence his attitudes. A participant may see himself as a source of difficulty for the first time. He may see his superiors in a better light than previously. Where he previously saw subordinates as "sheep," "goats," or "wolves," he may now tend to see them as individual people with individual sets of needs. There have been many experiences in which personal relationships have improved, even in instances where a feud of long standing has existed. Attitude changes of this sort come as early as the second week for some. In other instances people's attitudes don't seem to be very much affected at all, but such people are usually in the minority.

The other type of result is behavior modification. Increased sensitivity results in a wide variety of constructive actions. In one company the union president reported to the management that the supervisory force had suddenly become more intelligent in its handling of people. Other results include faster and better training, lowered turnover, improved quality of work, redesign of supervisors' jobs to permit them to function more as managers, and less as rank-and-file operatives.

Interestingly, there have been many spontaneous and successful applications of skills learned to other problems. One example of spontaneous application helps demonstrate the program's effective-

Table 3—Subjects for Manager-Development Sessions

The job of man management. Factors which have made people increasingly difficult to please in recent years. Effect of these factors on management methods. What turnover, absenteeism, and other handicaps to business success cost, and what causes them. What man management consists of and requires.

You and others are all alike. Needs shared by all people who work. What happens when needs aren't satisfied. Relationship between need satisfaction, attitudes, and job performance.

You and others are all different. Differences in importance of various needs to specific people. Differences in ways that people show their needs, and why such differences develop. Need differences as a basis for disagreement. Analysis of one's own needs as a basis for explaining his own behavior.

Systematic personnel development. How every manager influences knowledge, skill, and attitude development. Controlling this influence by techniques that help get people off to a good start, and develop and maintain adequate performance.

Planning with human roadblocks in mind. Importance of planning. Misunderstandings and feelings as hindrances to plan achievement. Planning methods which both raise the quality of plans and facilitate the acceptance of changes, orders, and instructions. Planning applied to personnel development.

Talking about performance. Psychological necessity for and business advantages of chats about performance. Interviewing techniques for job performance discussions. Interviewing as a follow-up and two-way communication device.

Talking applied to daily remedial actions and grievance handling. Indifference, poor quality, low productivity, lateness, absenteeism, violation of regulations and other forms of nonco-operative behavior as symptoms. Grievances as symptoms. Manager responsibility for obtaining conformance and co-operation. Interview - based techniques for obtaining conformance and handling dissatisfaction.

Success reports and further applications. Feedback of achievements of group members to date. Application of viewpoints and skills obtained in program to other problem areas, such as dealing with older people, superiors, and so on. Discussion of plans of each group member for applying viewpoints and techniques learned.

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ness in dealing with problems generally.

A staff specialist was caught in the middle of a situation in which six different departments were involved in a procedural change. None was willing to make the minor adaptation which the modification called for. The specialist then tried working with each of the supervisors individually, and by use of the special interviewing techniques he had learned in the program he was able to draw out the objections of each. Once their objections came out in full view, they independently came to the conclusion that their own objections really weren't serious ones, and that there was no good reason for their not going along with the modification. The situation had been such a hot one that no one had previously listened long enough for both facts and feelings to be fully expressed.

Of equal and possibly of even greater significance is the revision of managers' concepts of their own role. As one manager said, "I never used to view myself as having a teaching responsibility. In fact, when my people came to me with questions I deliberately gave them the brush-off. I now find myself trying to do a systematic teaching job for the first time, and I already have found that I am less pestered with questions."

As another put it, "I used to consider that it was my job to think, and that of my group to do the work. By using the 'turnback' and other methods such as listening and 'finding out why' I have gotten some excellent suggestions. More and more I find myself delegating work to my subordinates that I ordinarily would do myself. They have done a good job of it, and I find more time to devote to other matters."

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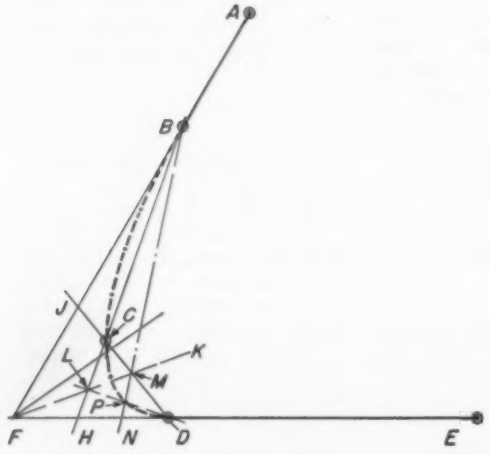
Tips and Techniques

Constructing Fair Curves

The following method has been found to give quite satisfactory results when it is necessary to join two lines, *AB* and *ED*, with a fair curve passing through a specified intermediate point, *C*.

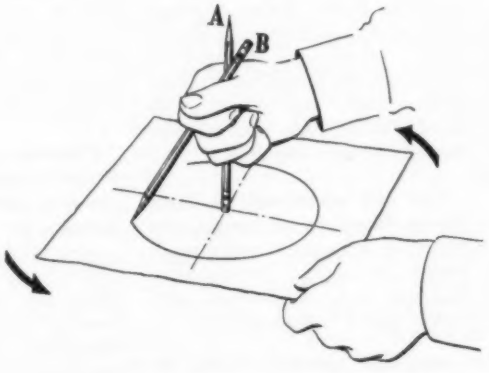
1. Extend lines *AB* and *ED* to intersect at point *F*.
2. Draw straight line *DC* and extend to intersect line *BF* at point *J*.
3. Draw straight line *BC* and extend to point *H*.
4. Draw line *FK* at any angle between lines *ABF* and *FDE* to intersect line *DCJ* at point *M* and line *BCH* at *L*.
5. Join *BM* and extend this line to intersect line *FDE* at point *L*.
6. Join *DL*. Intersection of line *DL* with line *BMN* at point *P* is then a point on the required curve.



Steps 3, 4, 5 and 6 may be repeated as many times as seems necessary to find as many points as are required on the curve.—C. DON LONG, *Ottawa, Ont.*

Drawing Impromptu Circles

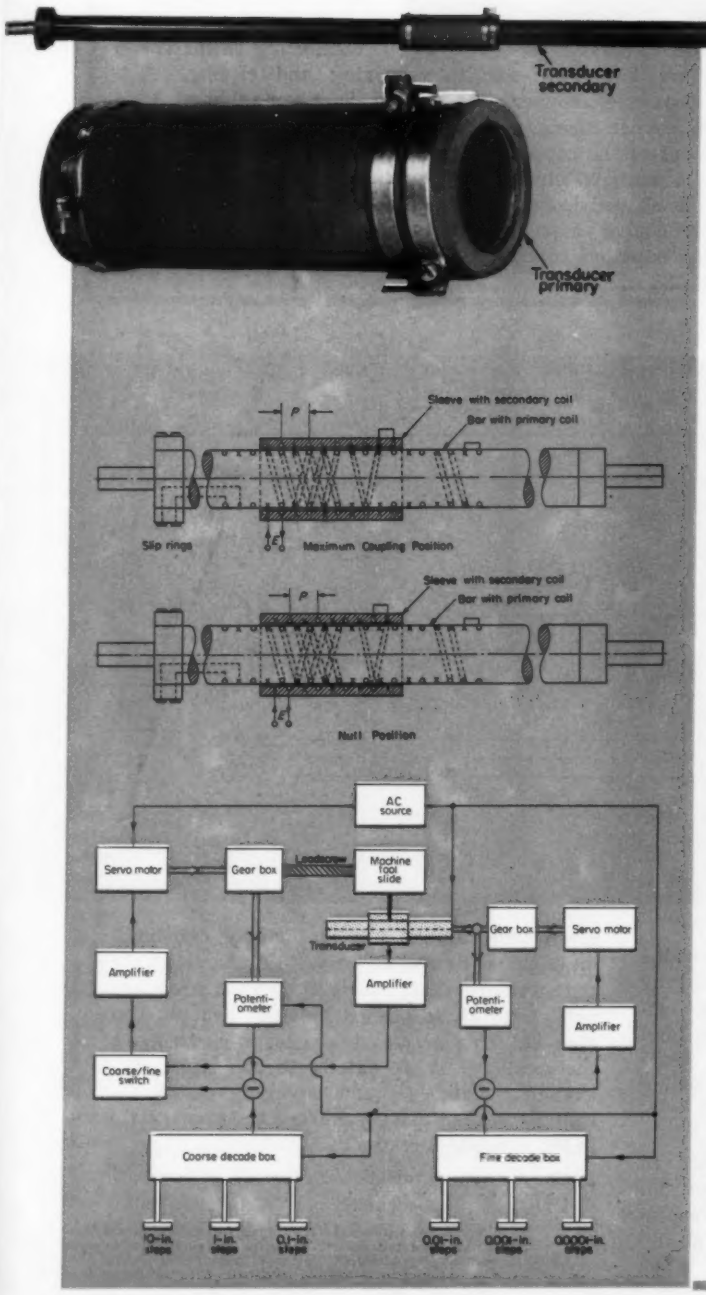
Reasonably accurate circles may be drawn without a compass, using two pencils as shown. The pencils and the hand holding them remain stationary while the paper is rotated.—J. D. PENRY, *Solar Aircraft Co., San Diego, Calif.*



Crosshatching With Disks

Metal disks or coins may be used as crosshatching guides simply by placing them in the center cutout of the triangle being used. Disk size depends upon cutout size and spacing desired. Disk and triangle are alternately held and moved.—WILLIAM T. DAROU JR., *Laboratory For Electronics Inc., Boston, Mass.*

scanning the field for *Ideas*



ACCURATE LINEAR POSITIONING of mechanical elements is offered by a new type of transducer construction developed at Canadian Westinghouse Co. Ltd. Designed for application in machines in which cutting tools must be precisely positioned, the transducer can measure linear displacements to accuracies of 0.0001-inch over distances of several feet.

In construction the unit is made up of two electromagnetically coupled parts —a primary and a secondary. The transducer primary consists of a bifilar coil wound in two insulated spiral grooves cut in a long cylinder. Leads from the primary are connected to slip rings. The secondary also contains a bifilar coil placed on the inside of a sleeve which can slide over the primary.

Primary and secondary coils can be physically aligned over each other to give maximum electromagnetic coupling. When the secondary is shifted so that its wires are midway between primary wires, voltages induced in the two adjacent primary-coil wires cancel each other. If the secondary is shifted further in the same direction until the wires line up again, induced primary voltage reaches a maximum of the opposite phase. The zero-voltage nulls appearing between voltage peaks as the secondary sleeve is moved along are used for linear positioning in this control circuit. Since the system is ambiguous, the transducer is employed for *fine* positioning only. A *coarse* servomechanism positions the machine slide to an accuracy of less than half the distance between transducer nulls. Then the fine system adjusts to the nearest null.

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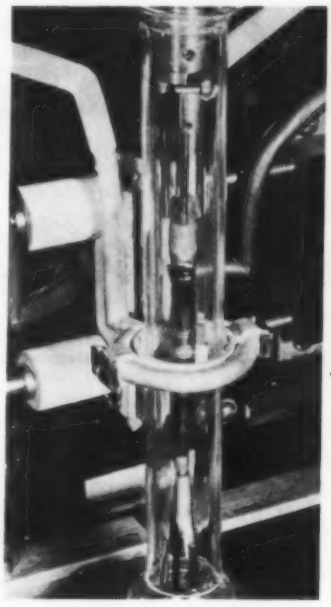
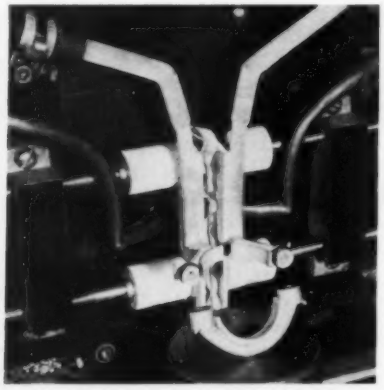
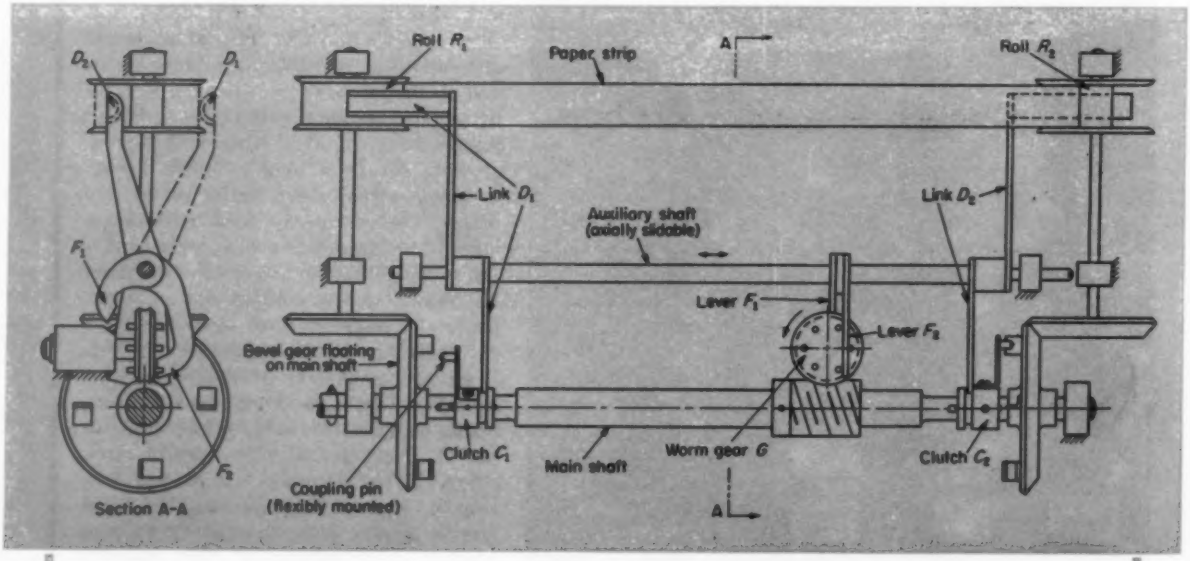




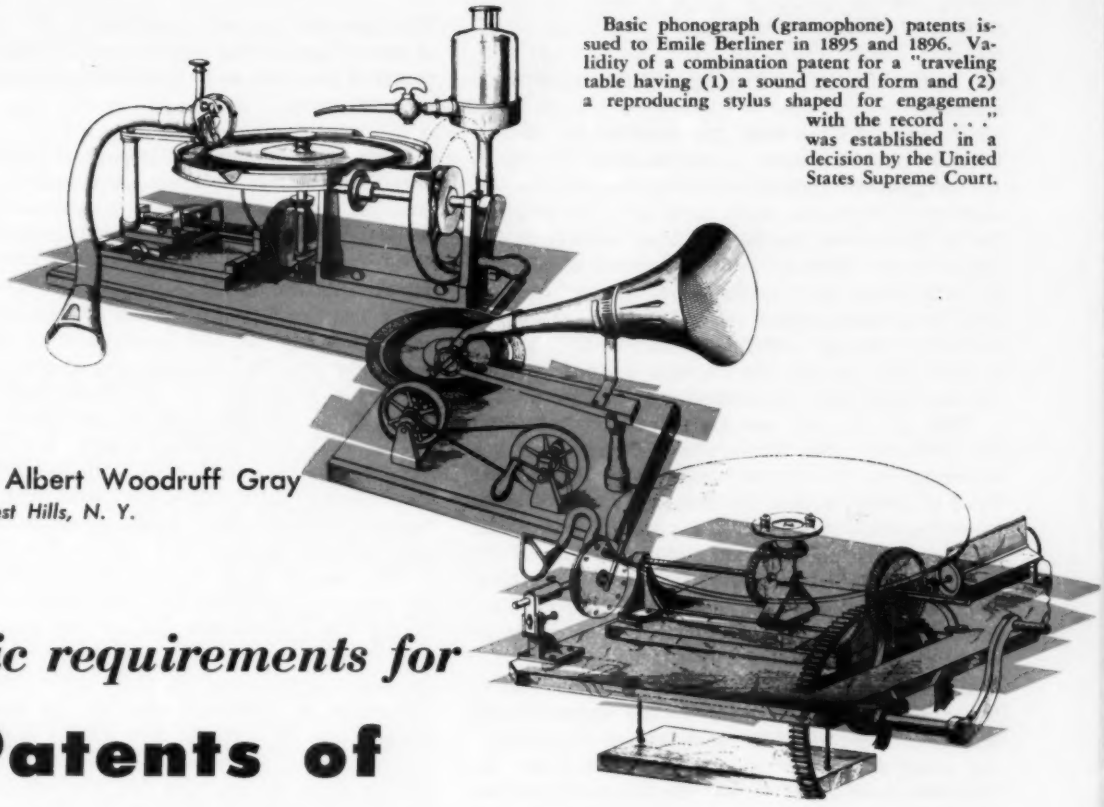
SPLIT INDUCTION COIL design permits heating workpieces that cannot be inserted into the coil because of shape limitations. Developed by Julius Soled of the Signal Corps Engineering Lab., Fort Monmouth, the design employs separate water cooling paths for each half of the coil with a rubber tube connecting them. The halves are hinged to facilitate opening and closing. A three-piece inner copper ring, which is silver-soldered to the split copper tubing, serves as the current path. A slight bowing out of the copper tubing at both sides provides room for sleeve joints which are sealed with rubber O-rings. Small, triangular-shaped copper projecting ears are gripped by beryllium-copper clips develop good pressure contact of inner silver-plated conducting path.



SMOOTH REVERSING ACTION is provided by a drive control mechanism developed by B. J. Popper of Kfar Ata, Israel. The assembly was designed to automatically and quickly reverse direction of roll-up of strips of paper without tearing the paper, shocking surrounding mechanisms or inducing high pressure on the strip rolls.

Single-direction rotating power applied to the main shaft is transmitted either to roll R_1 or R_2 by means of clutch C_1 or C_2, respectively. Only one clutch may be engaged at any given time. If clutch C_1 is driving, the build up of paper on roll R_1 causes link D_1 to rotate the auxiliary shaft slowly through a small arc until lever F_2 is pushed between two pins on gear G. This action causes lever F_2 to move the auxiliary shaft axially to the right, disengaging clutch C_1 and engaging clutch C_2. Roll R_2 is then driven, moving the paper strip in the opposite direction.

Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas," MACHINE DESIGN, Penton Bldg., Cleveland 13, O.



Basic phonograph (gramophone) patents issued to Emile Berliner in 1895 and 1896. Validity of a combination patent for a "traveling table having (1) a sound record form and (2) a reproducing stylus shaped for engagement with the record . . ." was established in a decision by the United States Supreme Court.

By Albert Woodruff Gray
Forest Hills, N. Y.

Basic requirements for Patents of Combinations

Practical facts about the patentability of inventions which utilize a combination of well-known or new design principles and components

TO BE valid, patents of combinations must possess one feature that is vital: the combination must be an invention in itself, not merely an aggregate of the parts or elements of the combination. There is no patentable invention in a combination when, as one court expressed the principle, "Two and two have been added together and still make four."

A good example that illustrates this fundamental requirement is the familiar combination of sodium and chlorine. The product is not merely the combination of these two elements, but it is a third—ordinary table salt.

Element of Invention: In the decision of a patent infringement action by the United States Supreme Court is a brief description of the invention for which the patent had been issued: "A cashier's counter equipped with a three sided frame or rack, with no top or bottom, which when pushed or pulled will move groceries deposited within it by a customer to the checking clerk and leave them there when it is pushed back to repeat the operation. It is kept on the counter by guides."

Suit had been brought for the infringement of this patent against a company with a chain of self-service grocery stores. In its defense that company asserted that similar devices had been used before and that when the need became apparent practically all self-service stores put them in at the same time although their owners had never heard of nor seen this combination. In short, as there was no patentable invention, there was no patent infringement.

By the United States District Court, where the action was first heard, it was held that here was a valid combination patent. From this adverse decision the protest of this chain store company against the claimed patentability of this combination was appealed to the United States Court of Appeals for review. There the decision of the lower court was sustained but with an adverse note in

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the dissent of one of the judges of that court who asserted:

"It seems to me that the combination of the admittedly old elements as described in the claims (of the patent application) does not rise to the dignity of invention. Quite apparently the originator of this device derived the idea underlying his patent from a different field by utilizing a commonly known and long existing art, that of racking pool balls upon a pool table. In effect he merely opened up the apex of an ordinary pool ball rack so that the legs of the triangle became parallel to each other and perpendicular to the base.

"The opened rack was then hand pushed along an elongated table. The pushing element was not automatic or even mechanical. The result achieved by this simple method undoubtedly was utilitarian when applied to self-service grocery stores, for merchandise could be pushed along faster and the purchaser better served. But that, to my thinking, does not constitute this combination of old elements inventive to the degree that a patent monopoly should be granted."

A few months later the decisions of both these lower courts were reversed by the United States Supreme Court and the conclusion of the dissenting judge adopted as the law. In its decision, the Supreme Court said: "Courts should scrutinize combination patent claims with a care proportionate to the difficulty and improbability of finding invention in an assembly of old elements. The function of a patent is to add to the sum of useful knowledge. Patents cannot be sustained when, on the contrary, their effect is to subtract from former resources freely available to skilled artisans. A patent for a combination which only unites old elements with no change in their respective functions such as presented here obviously withdraws what is already known into the field of its monopoly and diminishes the resources to skillful men. This patentee has added nothing to the total sum of knowledge but has merely brought together segments of prior art and claims them in congregation as a monopoly."

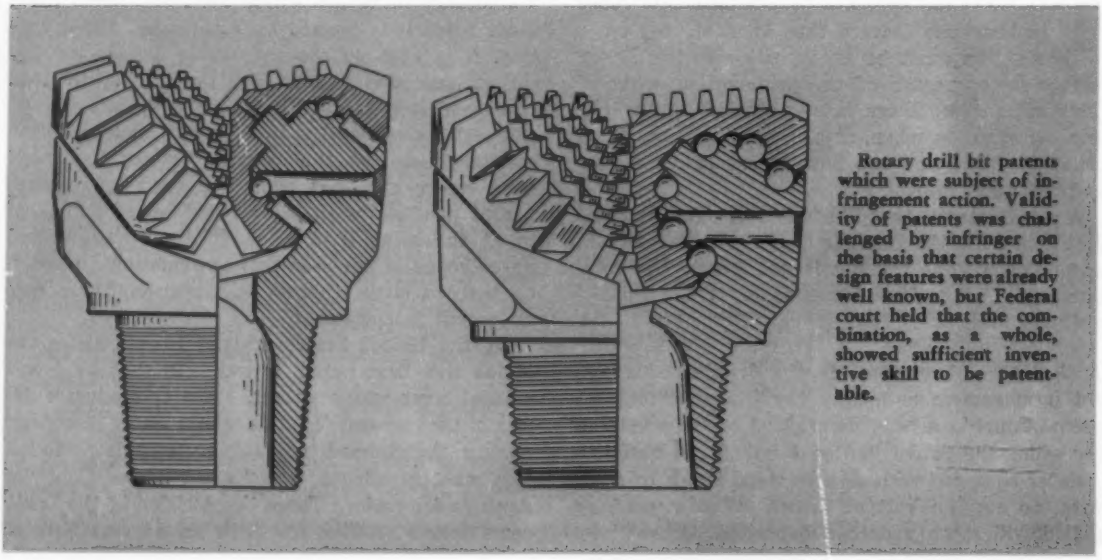
Basic Legal Distinction: In another decision, with regard to the law underlying the combination patents of the phonograph, that court said of the distinction between the inventions which are the elements making up the combination and the combination itself:

"A combination is a union of elements which may be partly old and partly new or wholly old or wholly new. But whether new or old, the combination is a means—an invention—distinct from them. They, if new, may be inventions and the proper subject of patents, or they may be covered by claims in the same patent with the combination. But whether put in the same patent with the combination or made the subjects of separate patents, they are not identical with the combination.

"To become that they must be united under the same co-operative law. Certainly one element is not the combination nor, in any proper sense, can it be regarded as a substitutive part of the invention represented by the combination, and it can make no difference whether the element was always free or becomes free by the expiration of a prior patent, foreign or domestic. In making a combination, an inventor has the whole field to draw from. This view is in accordance with the principles of the patent laws."

In a recent infringement suit it appeared that the combination patent claimed to have been infringed was merely a combination of methods already old. The Federal court in this instance said of patents of this character:

"The general propositions of law applicable to combination patents are not difficult either to state or to understand. A combination is a union of elements, some of which may be old and others new or all old or all new. It is the combination which



Rotary drill bit patents which were subject of infringement action. Validity of patents was challenged by infringer on the basis that certain design features were already well known, but Federal court held that the combination, as a whole, showed sufficient inventive skill to be patentable.

is the invention."

This general statement, however, the court restricted with the comment, "But the result must be a combination and not a mere aggregation of several results, each a complete product of one of the combined elements. It must be the product of the co-acting influences of the various elements and which is produced by their union.

"A number of old parts or elements which in the aggregation perform or produce no new or different function or operation than that theretofore performed or produced by them, is not a patentable invention."

Application of Law: This rule, which must perforce govern the validity of patents on automatic machinery, that the whole must be an invention rather than a combination of the inventions of mere parts, is old in the patent law. Difficulty comes in the application of the rule in determining both the extent and character of the advance of the whole over the inventions expressed in the different parts composing the combination.

Before a Federal court a few years ago there was brought for review a decision in an infringement action based on a combination patent of rock drills. In an earlier decision that court had said, "A new combination of old elements from which a new and useful result is obtained or whereby an old result is obtained in a more facile, economical and efficient way, is patentable, provided the discovery and reduction to practice of the novel combination requires greater skill and higher thought than would be expected from the ordinary mechanic."

In another and more recent action of this character brought by the same rock drill manufacturer for the illegal use of rotary drilling bits used in oil well drilling, the defense was that these combination patents were invalid both for lack of invention and that they had been anticipated by earlier patents.

The patentee's description of the invention covered by these patents was, "The arrangement of three conical cutters with teeth interfitting and with rows of teeth arranged so that each row will cut a different track on the bottom of the hole and also leave sufficient support for the cutter, so that they will withstand heavy duty. By making the teeth interfit the cutter shells may be made larger and the shaft may be strong enough."

Of this combination the court made the comment that, "Though three cone non-interfitting patents had been known for years but had not been used, these inventors were the first to discover and develop an interfitting workable three cone bit.

"When we consider as to the three patents in suit, their great usefulness, their uniform use in deep drilling where they operate thousands of feet underground, that they have stood without successful challenge for nearly the allotted span of their lives and that it is very easy after a discovery to determine that the discovery was obvious, we are of the firm opinion that the presumption following the granting of this patent, aided as it is by long public acceptance and use and the opinion of the patentee's expert, and supported by judicial approval, far outweighs the opinion of the alleged infringer's expert that because some of the elements of these combination patents are well known, the patents show no novelty and the combinations they represent are anticipated.

"We think this takes too narrow a view of the applicable patent law. A combination is patentable though each of its constituent elements was well known in the prior art, if the combination produces a new and useful result and not merely the aggregate of several old results, or if it produces an old result in a cheaper or otherwise more advantageous way.

"It is true that the combination must represent something more than the ordinary skill of the average mechanic, but speaking prosaically rather than poetically, it is not true as it is sometimes claimed, that patents to be valid must be the result of, must embody, flashes of genius.

"When confronted with a combination producing a materially different or more advantageous result, one must examine the particular change made in the light of the art at the time the device was developed, to determine whether inventive skill produced the change or whether only mechanical aptitude was responsible."

In holding that an alleged invention of a method for the manufacture of moulding crucibles lacked the features for a patent, the Supreme Court summarized the principles governing the patents of combinations of old elements:

"In a patentable combination of old elements, all the constituents must so enter into it as that each qualifies every other. To draw an illustration from another branch of the law, they must be joint tenants of the domain of the invention, seized each of the other part, by the half and by the whole, and not mere tenants in common with separate interests and estates. It must form either a new machine of a distinct character and function or produce a result due to the joint and cooperate action of all the elements and which is not the mere adding together of separate contributions. Otherwise it is only a mechanical juxtaposition and not a vital union."

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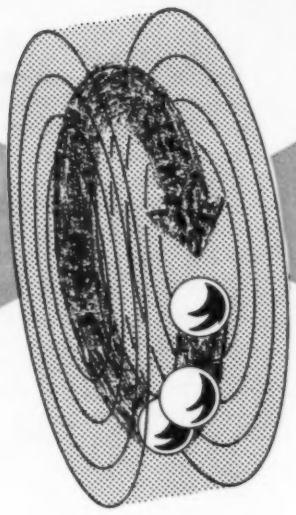
3. Berghane v. Radio Corp. of America, 116 *F.S.* 200, October 22, 1953.
4. Williams Iron Works Co. v. Hughes Tool Co., 109 *Fed.* 2d 500, January 13, 1940.
5. Robertson Rock Bit Co. v. Hughes Tool Co., 176 *Fed.* 2d 783 August 13, 1949.
6. Pickering v. McCullough, 104 *U.S.* 310, October, 1881.

"No company can afford to say that its engineers competent to do research and development are too valuable to be assigned to other work, for they are so valuable to the functioning as a whole that some must be assigned broad management responsibilities."—COLONEL O. G. HAYWOOD, *USAFR*.

Ball Bearings for High Speeds



By Heinz Hanau, *Supervisor, Aircraft Projects*
New Departure Div.
General Motors Corp.
Bristol, Conn.

HIGH speeds—particularly when coupled with high temperatures—are a problem for conventional ball bearings. Ball bearings designed and constructed for *DN* values (bore in mm times speed in rpm) of 500,000 or less can hardly be expected to operate suitably at 1 million *DN* and over.

One area where present bearing speeds have proved to be a limitation is in gas turbines for aircraft. Although high speed problems are by no means limited to this area, gas turbines can serve as a fairly typical illustration of the demanding requirements for new bearings.

Present-day planes are flying at Mach 2, and planes are in the development stage to fly at speeds exceeding Mach 3. For these aircraft, turbine bearings will probably have to operate at *DN* values to 2×10^6 at fairly high thrust loading. Ball bearings capable of operating at temperatures of 500 to 700 F will have to be furnished, with the ultimate goal of 1000 F operation.

Although these figures may seem extreme, they are indicative of the trend in all kinds of equipment. Speeds continue to go up, and so do temperature requirements.

The purpose of this article is to acquaint the de-

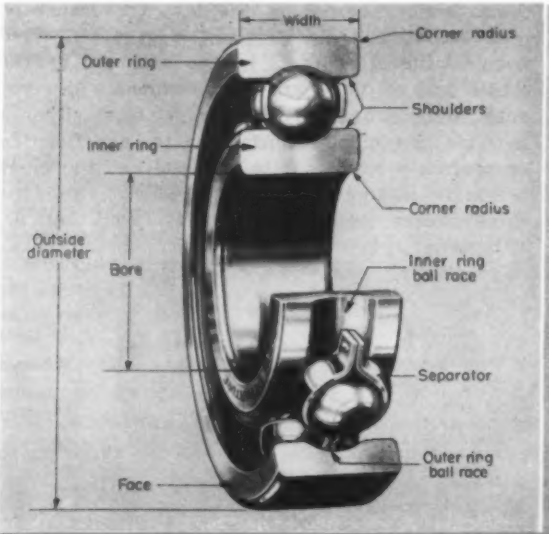


Fig. 1—Conventional deep-groove radial ball bearing, which can be used for speeds up to 0.3-million *DN*.

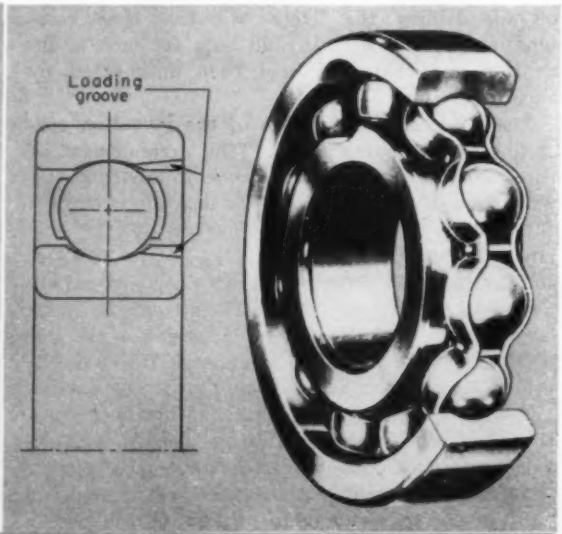


Fig. 2—Filling-notch bearing, which has a speed limitation about the same as the deep-groove type.

How to engineer and apply special bearings for high speeds and high temperatures

- Basic bearing geometry
- Separator design and materials
- Special bearing configurations
- Bearing materials
- Lubrication
- Mounting fits and clearances
- Causes of bearing failure

signer with the problems of high speeds in ball bearings, and also those of high speeds coupled with high temperatures. It outlines to what degree some of these problems have been solved, and what is being done to improve bearing reliability. Practical design considerations of bearing configuration, types of separators, mounting, lubrication, materials, and effects of clearances are covered.

Standard Ball Bearings

Ball bearings listed as standard in catalogs have definite temperature and speed limitations. All types described in the following section are manufactured of SAE 52100 steel which can be used at temperatures to 300 F. With special ring and ball stabilization added, these bearings can be operated to temperatures of 400 F. In lightly loaded applications it is possible to operate bearings with special stabilization somewhat in excess of 400 F.

The conventional deep-groove, radial type ball bearing employing a two-piece, rivet-assembled, ribbon type separator is shown in Fig. 1. Safe speeds of operation of a bearing of this type under good conditions of lubrication are between *DN* values of 0.2×10^6 and 0.3×10^6, depending on bearing size.

The loading-groove or filling-notch type of bear-

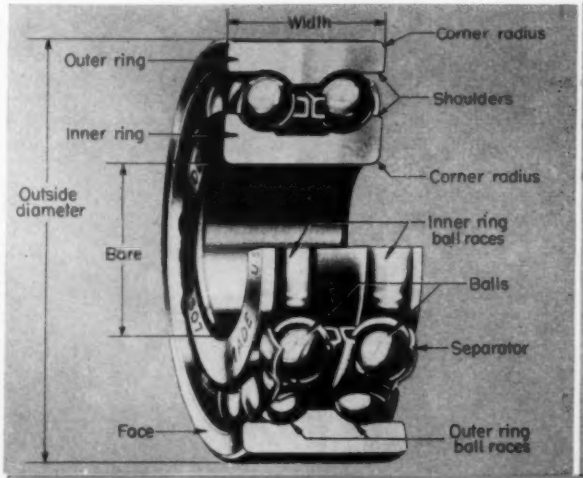


Fig. 3—Double row ball bearing, not usually operated at speeds above 0.2-million *DN*.

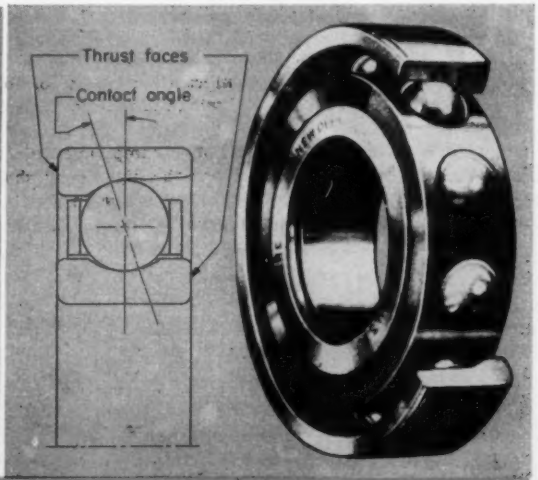


Fig. 4—Angular-contact bearing, the fourth standard type employed for moderate speeds.

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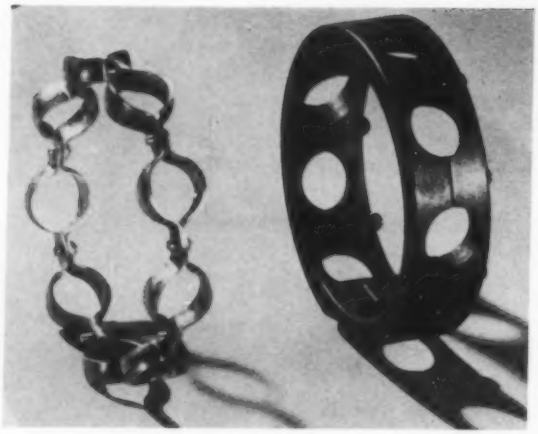


ing, Fig. 2, enables more balls to be assembled into a given envelope, resulting in a higher radial capacity bearing. This bearing should only be operated under moderate thrust. About the same speed limitation applies as for the deep-groove bearing.

The double-row ball bearing, Fig. 3, is not normally operated above 0.2×10^6 *DN*.

The fourth basic type of conventional bearing is the angular contact, Fig. 4. Because of the low thrust shoulder on one outer ring side, it is pos-

Fig. 5—Left—Cages used for deep-groove bearings: left, a rivet-assembled pressed-metal type and, right, a two-piece phenolic cage. The latter has been used to 1 million *DN*.

High-Speed Bearings in

HIGH-SPEED ball bearings require careful attention to mounting and lubrication. The following examples show how high-speed bearings are used in gas turbine engines and turbo accessories.

Aircraft Refrigeration Turbine

Bearings in 8 to 15-mm bore sizes, Fig. *A*, operate at 75,000 to 120,000 rpm under scant and often inadequate lubrication. The assembly is exposed to reversing and varying thrust loads as well as rotating radial loads due to unbalance.

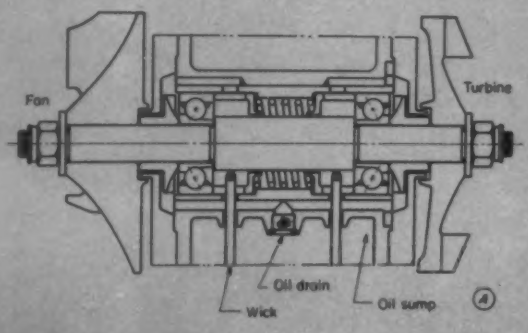
Ultrahigh-speed bearings with one-piece outer ring riding pressed-metal cages are employed, although deep-groove bearings with inner ring riding cages are being successfully used to the 1 million *DN* range.

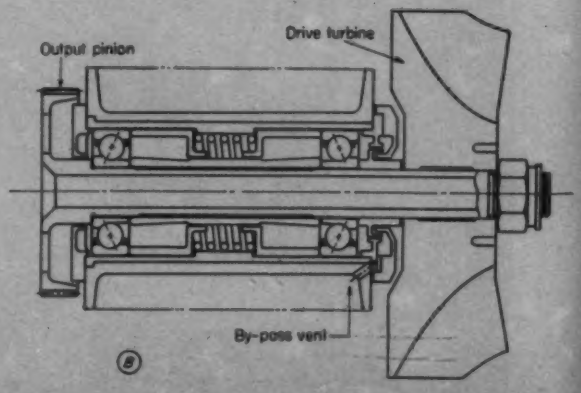
Weight and bulk limitations prevent use of oil pumps; successful grease lubrication is not possible. Therefore, recirculating oil wick lubrication is necessary.

The wick feeds oil from the sump and unloads it at the point of contact with the high-speed shaft, where it is thrown off into the space in front of the bearing. Suction slingers behind the bearings create a circulating air current which forces the oil mist through the bearing. Some oil is thrown out of the air stream and returned to the sump through the return passages, but most of it is recirculated through the bearings through the bypass slots in the housing. In effect, two independent oil lubrication systems are shown; one for each bearing. This helps to prevent lubrication starving of either bearing.

Bearing mounting is of the reversible type, designed to support thrust in either direction and by either bearing. When the external thrust load exceeds the preload spring force, the rotating assembly moves axially until the spacer seats against the thrust shoulder in the housing. A preload thrust will continue to be applied against the unloaded bearing, a very necessary feature in a high-speed bearing.

This type of mounting avoids the highly undesirable condition of contact-angle reversal during thrust reversal. As the thrust reverses, the bearing contact angles stay in the same relative position of angularity, and the whole rotating assembly moves over against the opposite housing shoulder





sible to assemble this bearing with a greater complement of balls than a deep-groove bearing and to employ a one-piece cage. The bearing should never be employed without thrust being applied against the thrust shoulder, either by spring loading or preloading as a matched pair.

The pressed-metal and the phenolic or nonmetallic types of cages used in deep-groove ball bearings are shown in Fig. 5. Both are rivet assembled and of two-piece construction. The latter type of cage can be employed up to *DN* values of 1×10^6, is land riding, and has straight-sided ball pockets.

A four-piece WD separator is shown in Fig. 6. This represents one of the first attempts at designing a light, high-speed and high-temperature separator which, in suitably stabilized bearings, is being successfully operated at temperatures to 400 F and *DN* values of over 1×10^6 with oil lubrication. This separator is usually fitted into a single-row, deep-groove bearing. The saddle is made of a bronze material and the ribbon piece is of bronze-bonded SAE 1010 steel.

While work is in progress to investigate the possibility of using ball-controlled separators at high speeds, it has heretofore not been found economically feasible to manufacture a ball-controlled type of cage on a production basis that will give satisfactory service at high speeds.

When bearings have to be operated at speeds above 0.3×10^6 *DN*, it is generally advisable to use

Turbines and Turbine Accessories

without the spring preload on the bearings being relieved.

Several bearing sizes are operating satisfactorily at *DN* values in excess of 1.1×10^6 with operating temperatures up to 400 F. Major difficulties are those of providing adequate lubrication to both bearings at all times, particularly under varying conditions of altitude and temperature, as well as the problem of adequate shaft balance since only the slightest overspeed condition can cause stretching of parts with resultant destruction of the balance originally built into the unit. Dynamic balancing of the rotating assembly in such a unit should be done to better than 0.0005-oz-in.

Alternator Drive Turbine

A reversible mounting with maximum capacity bearings is used, Fig. *B*, with an outer ring riding pressed-metal separator. The cavities surrounding the bearings are entirely filled with grease.

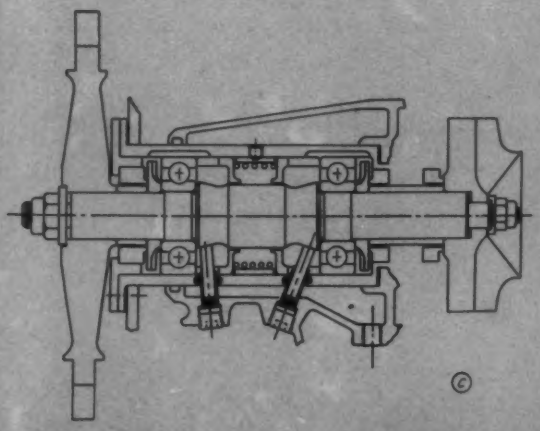
A very simple type of closure is provided at the output pinion end of the shaft, but a more complicated seal is necessary in the drive turbine end. The turbine end seal incorporates a plenum chamber connected to vents which bypass hot leakage gases and prevent them from getting into the bearing housing.

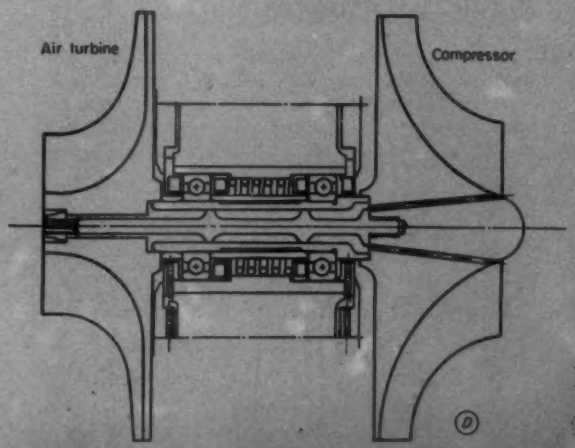
Bearings have been furnished for this type of unit which have operated successfully with grease lubrication at *DN* values in excess of 500,000 for periods as long as 500 hr.

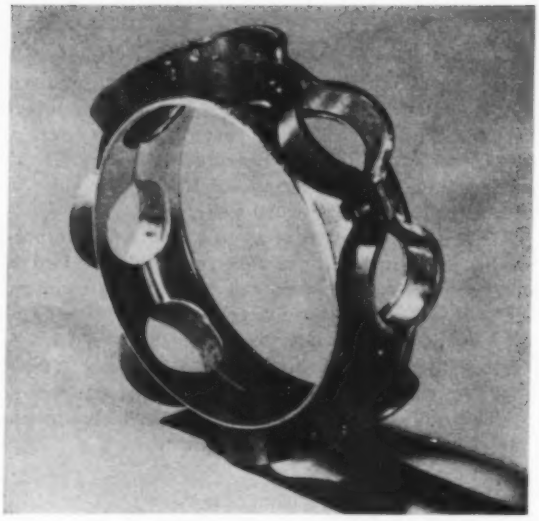
High-Temperature Fuel Pump

Bearing mounting design, Fig. *C*, is for an installation where comparatively short life is required.

Reversing type of mounting and wick oil lubrication is employed. Two spring-preloaded wicks feed oil from the annulus surrounding the housing to the bearings. The uniqueness of this application







ring-controlled separators. Generally, the use of either inner or outer ring-controlled separators, such as the WD type, or the nonmetallic type shown previously, are recommended. With the nonmetallic type, the top temperature limitation of the bearing is generally 250 F, although in special cases successful operation has been obtained at temperatures to 300 F for short periods of time.

Bearing Geometry

Basic Relationship: The load-carrying elements of a ball bearing consist of inner and outer race-

Fig. 6—Left—Four-piece pressed-metal separator, a first attempt at designing a light separator usable at temperatures to 400 F and *DN* values of over 1 million.

High-Speed Bearings in Turbines and Turbine Accessories *(continued)*

is only in the very high temperature at which this unit has to operate for a short period of time. The comparatively cooler fuel being pumped jackets the lubricant and protects it from the very high ambient temperatures, believed to be in the neighborhood of 900 F.

Air Compressor

A turbine-driven air compressor, Fig. *D*, operates at *DN* values to 1 million. A bearing mounting with grease cavities surrounding both bearings is employed. Uniqueness of this design is the hollow shaft and tie-bolt assembly. This was done to minimize heat transfer from the hot turbine and compressor disks to the bearings. Air is drawn through the center of the bearing shaft for additional cooling.

Small Gas Turbine

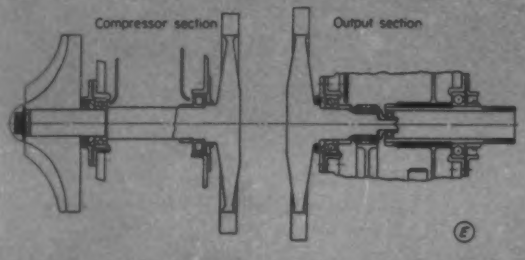
A split inner ring bearing operating in the neighborhood of 1 million *DN*, Fig *E*, supports thrust load from the compressor section of a small gas turbine engine. Oil-jet lubrication is employed. Operating temperature of the bearings in this type of application is not more than 300 F. Turbine-end bearing of the output section is also oil-jet lubricated.

Compressor section operates at approximately 35,000 rpm, and the output section at approximately 25,000 rpm with a reduction to 6000 rpm for the power output shaft.

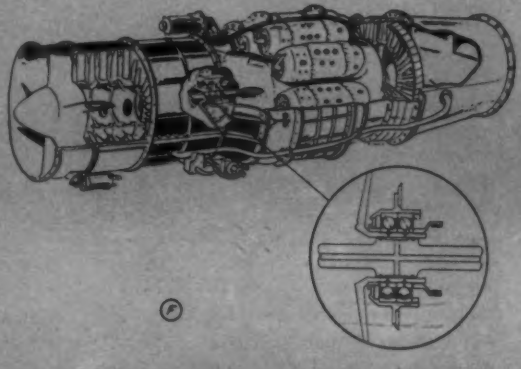
Specially designed high-speed bearings have operated successfully for over 500 hr between overhauls in several of these small gas turbine engines.

Jet Engines

A typical jet engine mainshaft bearing application employing two matched sets of split inner ring bearings is shown in Fig. *F*. Jet-engine mainshaft bearings of this type, some of which are operating satisfactorily at *DN* values over 1.4×10^6 with thrust loads up to 10,000 lb and outer ring temperatures in the neighborhood of 375 F, are being made in sizes ranging up to 220-mm bore.



E



F

ways and balls. The raceways are made slightly larger than the ball radius. The terms customarily employed in ball bearing geometry are:

d = Ball diameter
f_i = Inner race radius (fraction of d)
f_o = Outer race radius (fraction of d)

Standard ball bearings have f_i within 51 to 52 per cent and f_o within 52 to 53 per cent.

A certain amount of internal clearance between balls and races is built into a bearing. This radial clearance, which can also be expressed in terms of bearing end play, is geometrically related to the bearing contact angle created when the inner and outer races are displaced relative to each other in an axial direction. The contact angle is formed by the angularity between an imaginary line drawn through the inner and outer race ball contact points and a line through the ball and bearing centers.

The mathematical expression relating contact angle, radial clearance and race curvature is:

$$\cos \beta = 1 - \frac{P_d}{2Bd} \qquad (1)$$

where β = contact angle; P_d = radial clearance; and $B = f_i + f_o - 1$.

Rolling and Sliding Contact: When a load is applied to a bearing, the ball and raceways are deformed, and the contact changes from a point to an ellipse whose shape depends essentially on race curvature and the magnitude of the imposed load. The stress distribution on the contact ellipse resulting from the ball load P is shown in Fig. 7, both pictorially and mathematically. The X axis of the ellipse is parallel with the bearing axis.

Basically, three types of motion can occur on the contact ellipse: (1) pure rolling and (2) sliding in the direction of ball rotation, and (3) sliding due to relative motion between ball and raceway around the contact line, referred to as the axis Z. The first two types of motion are always present in a bearing while the third type, which is the most undesirable of the three, is usually present only in bearings under thrust loading.

The condition of rolling and sliding occurring on the contact ellipse of a bearing under pure radial load should be analyzed first.

The contact ellipse is curved along radius r, derived from the Hertzian theory that the indentation of bodies of similar material produces a common curvature, Fig. 8. On this deformed elliptical surface two points will have conditions of zero relative sliding; i.e., theoretically pure rolling.

Under zero load, only point contact exists between ball and races, and pure rolling will occur at the contact points, much the same as at the pitch circles in a planetary gear set. As load is applied to the bearing, and the point contact changes to a curved elliptical surface, the "pitch circle" (still using the planetary gear analogy) will shift to a position closer to the ball center than under condition of point contact.

If a line parallel to the ball axis is drawn at the new "pitch circle," the line intersects the curved elliptical surface twice. These lines represent the instant centers of rolling, and the points of intersection the positions of pure rolling or zero sliding. The position of these two points can be mathematically determined from the relative sliding velocities and race deformation.

On the portions of the elliptical surface on either side of the line of instant center, sliding occurs in opposite directions. Force $\Sigma f S_2 \Delta A$, Fig. 9, is the product of the coefficient of friction, the ellipsoidal stress distribution on the surface and the surface

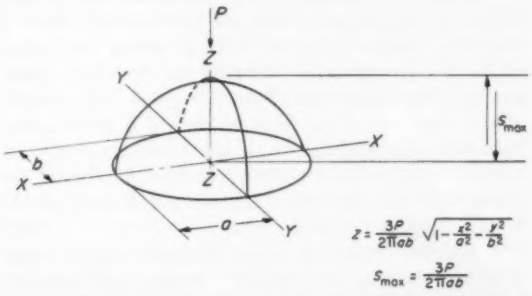


Fig. 7—Basic stress and deflection relationships resulting from ball and race deformation when a ball bearing is loaded.

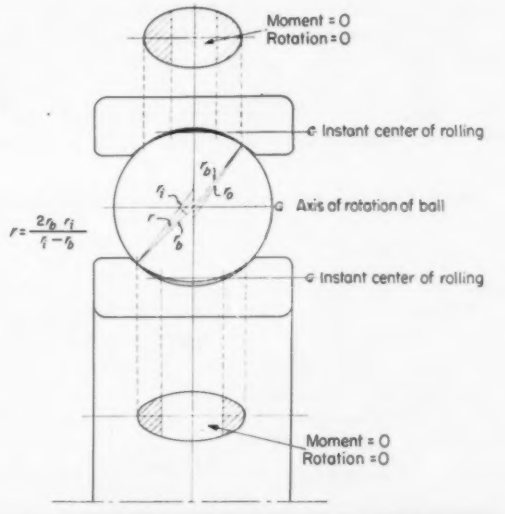


Fig. 8—Deformation of ball and races under pure radial load. Pure rolling occurs only at the instant centers of rolling.

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area between the two lines of zero sliding. It acts in a direction opposite to forces $\Sigma fS_1\Delta A$ and $\Sigma fS_3\Delta A$. The latter two forces are equal to each other, and the total summation of sliding forces on the ellipse is zero.

In view of the symmetrical position and equality of the sliding forces on the contact ellipse of a bearing under pure radial load, no tendency exists for the ball to have relative rotational motion around axis Z, or the third type of motion previously referred to. The only condition of sliding or nonrolling will be in the direction of ball rotation.

If a bearing is subjected to thrust loading, axial displacement of the rings will take place and the bearing will operate under a contact angle β, Fig 10.

The lines of instant center will then try to converge on a common point on the bearing axis to maintain points of pure rolling, much the same as in a tapered roller bearing or, to use a gear analogy, the pitch line of conical gears. Symmetry of the location of the lines of zero sliding is thereby destroyed, and the resultant unbalanced $\Sigma fS\Delta A$ forces will cause relative rotational motion between ball and raceway around the Z axis of the ball, on one of the ball races.

A bearing operating under a small contact angle is shown in Fig. 10. The outer race curvature is larger than the inner race curvature, resulting in a larger contact ellipse on the inner race than on the outer race. The moment resisting relative rotation about the Z axis, as explained on Fig. 9, is therefore greater on the inner race ellipse than on the outer race ellipse, and relative rotation about the Z axis will therefore occur at the outer ball race contact point.

Inner race lines of instant centers will remain at right angles to the contact line, and the outer race line of instant centers will skew to intersect at a common point on the bearing axis.

Distribution of the $\Sigma fS\Delta A$ forces, as represented by the shaded and unshaded areas on the outer race contact ellipse shown on Fig. 10, gives rise to relative rotative motion around the Z axis at the outer race contact point.

As the contact angle β of the bearing is increased, angularity of the lines of instant centers increases to the point where only one point of zero sliding remains on the contact ellipse. The resulting unbalanced $\Sigma fS\Delta A$ forces are increased, and the rate of relative rotational motion about the Z axis of the ball is increased. A bearing with large angularity of the lines of instant center and only one point of zero sliding on the outer race contact ellipse is shown in Fig. 11.

Relative rotative motion against the ball races causes heating and premature surface failures and imposes a restriction on the size of the contact angle which can be built into a bearing, particularly as speed of rotation increases. Bearings operating at conventional speeds have been made with nominal contact angles up to 40 deg. Present practice is to restrict the contact angles of high-speed bearings to 25 deg.

The theory of relative rotation about the Z axis can be carried further into the high speed range. A ball bearing is considered to be operating in the high speed range when the centrifugal force effect

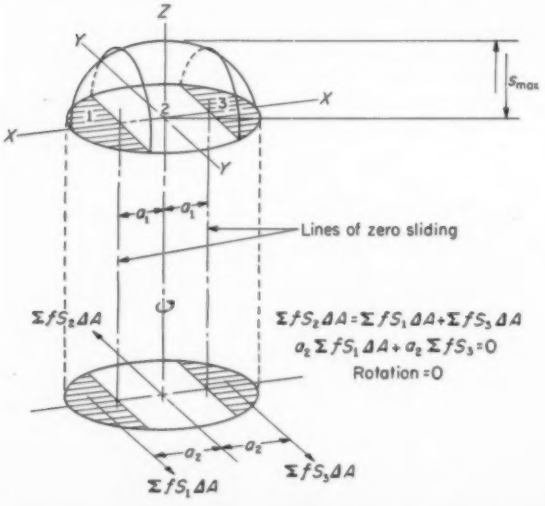

Fig. 9—Distribution of frictional forces at the ball and race contact area.

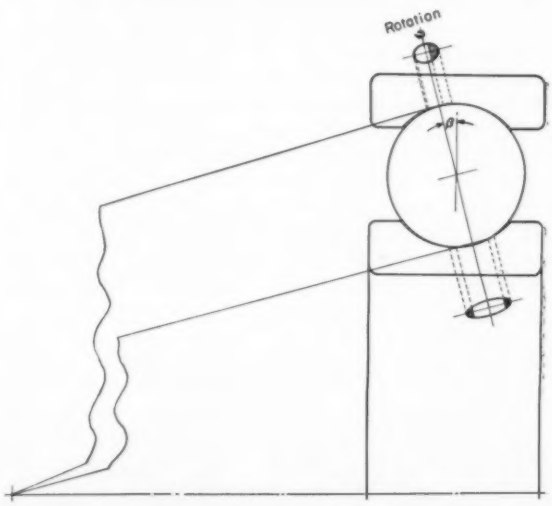

Fig. 10—Sliding forces on the ball contact ellipse for small contact angles. Because of unbalanced frictional forces, the ball rotates around a vertical axis.

of the balls becomes noticeable both from a load and geometry standpoint.

Due to centrifugal force effect, the balls have a tendency to centralize themselves on the outer race, thus reducing the outer race contact angle from β to β_o. This produces a radial clearance in the bearing which permits an axial shift of the inner race with respect to the outer race, resulting in an increase in the inner race contact angle from β to β_i, Fig. 12. Each ball in the bearing is thus operating at two different contact angles which gives rise to an additional type of sliding.

A bearing having unequal contact angles β_o and β_i as a result of high-speed operation is shown in Fig. 13. The outer race contact ellipse is larger than the inner due to the ball centrifugal force loading on the outer race. Based on the theory that the larger contact ellipse will have the greater moment, relative rotation about the Z axis would occur on the inner race.

High-Speed Geometry: In addition to the resistance to rolling present at conventional speeds, bearings operating at high speeds and under thrust loading are subjected to:

1. Relative rotative motion of the ball about the Z axis at one of the race contact points.
2. Sliding effect due to operation at different contact angles β_i and β_o.
3. High centrifugal force ball loading against the outer race.
4. Increased effect of gyratory forces on the balls.
5. Certain other high-speed loading phenomena not as yet fully understood but being invetigated, including hysteresis effect of the rolling elements.

Relative rotational motion about the Z axis can occur at either ball race depending upon the size of the respective contact ellipses. Fig. 13 shows the motion to occur on the inner race. By suitable choice of inner and outer race curvatures it may be possible to transfer the motion to the outer race in spite of the heavier ball loading.

It is believed, and some preliminary laboratory testing tends to confirm this, that lubrication of the outer race is considerably enhanced by the centrifugal force effect which throws the lubricant against the outer race and by the ability of the balls to entrap a greater amount of oil as a result of their high rotative and translational velocity. Conversely, the inner race will have a tendency to become starved of lubricant.

In view of this fact, it would appear desirable to have the motion around the Z axis occur between the outer race and the ball. Sliding would then be supported by an oil film which would minimize wear. However, the small inner race radius required to produce the necessary contact ellipse surface would give rise to considerable heat generation on the scantly lubricated inner raceway.

The degree of sliding caused by the operation at two contact angles β_o and β_i can be minimized by using the widest possible race curvatures which bearing capacity requirements permit. By applying a thrust load, whose magnitude can be determined on the basis of bearing size and operating speed, it is possible to make the two contact angles β_o and β_i approach the value of the original contact angle β and thereby reduce sliding. However, added heating effects may be encountered. Investigations are in progress to establish these design criteria.

Centrifugal force ball loading of the outer raceway in a high-speed bearing, which causes the

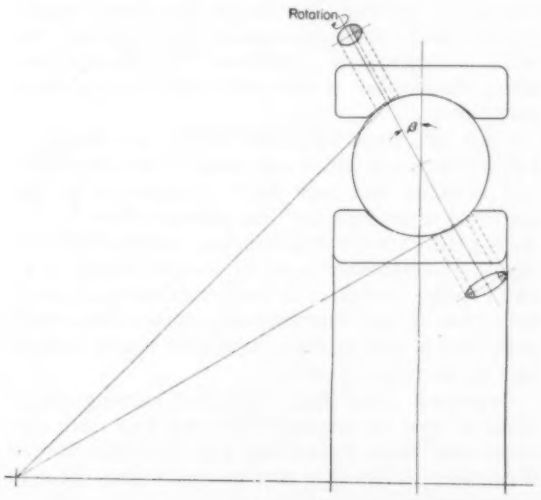

Fig. 11—Effect of large contact angles on distribution of sliding forces. At angles this large, there is only one point of zero sliding on the outer race.

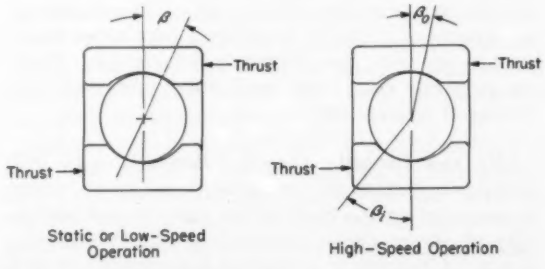

Fig. 12—Contact angles during low-speed and high-speed ball-bearing operation.

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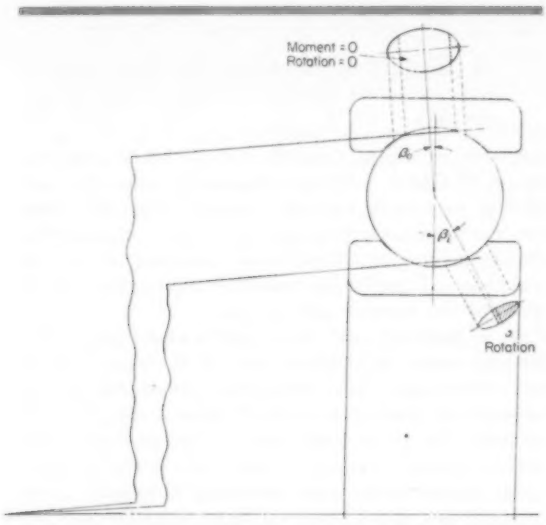

Fig. 13—Sliding forces in a high-speed bearing. Outer race contact ellipse is larger because of centrifugal force loading by the ball. Relative vertical rotation occurs on the inner race.

geometric relationship in Fig. 12, has given rise to the speculation that high-speed bearings will fail as a result of outer race fatigue, rather than inner race failure as is usually the case in bearings operating at conventional speeds.

Improved lubrication of the outer raceway and scanty lubrication of the inner raceway at high speed cause the centrifugal force ball loading on the outer raceway to be considerably reduced by the cushioning of the oil, and the ball sliding to be much more pronounced on the inner raceway. Both of these effects explain, to some extent, the continuing predominance of inner race failures in high-speed bearings.

Effect of gyratory moments of the ball can be minimized by reducing ball inertia and by having the smallest possible contact angle. The degree of importance of gyratory forces in a high-speed bearing has not yet been definitely determined. They are generally considered negligible in bearings operating at conventional speeds.

Life and Capacity Considerations: Life of ball bearings operating within conventional speed ranges is computed on the basis of the number and magnitude of stress cycles imposed on the rolling elements. A bearing of maximum life capacity should have:

1. Maximum ball diameter
2. Maximum number of balls
3. Minimum race curvatures

and, for maximum thrust capacity,

4. Maximum contact angle

In a bearing for high speed operation, all four parameters must be considered and a design compromise arrived at depending on the type of loading imposed on the bearing and the *DN* value of operation.

Although the effect on bearing life is not as severe as at first suspected, it is still desirable to minimize the ball centrifugal force loading. Ball centrifugal force varies as d^3 and basic bearing capacity, approximately, as d^2. A small reduction in ball diameter will therefore cause a greater reduction in centrifugal force effect than in capacity.

To illustrate the relative size range of ball centrifugal force and capacity, a 140-mm bore bearing operating at 10,000 rpm, 1.4×10^6 *DN*, has a thrust capacity per ball of 182 lb and centrifugal force per ball of 152 lb. A 10-mm bore bearing operating at 140,000 rpm, 1.4×10^6 *DN*, has a thrust capacity per ball of only 5 lb compared to the centrifugal force loading per ball of 26 lb. These capacities are based on the 10 per cent fatigue failure life of 760 hr.

For a given *DN* value the ball centrifugal force effect tends to be much more pronounced in small than in large bearings.

Choice of ball size is further dictated by the type of operation to which a high-speed bearing is subjected.

When bearings operate under combined loading, contact angles of the balls around the periphery of the bearing vary from a minimum for the ball directly under the radial load to a maximum value 180 deg away. This is due to both the radial displacement of the two bearing races relative to each other and to the angularity between inner and outer ball race centerlines caused by the combined loading.

Each ball contact point on the race represents a point on an orbit of different peripheral length. If inner ring rotational speed is held constant, the ball's instantaneous rotational and translational speed continuously varies with these contact angle variations.

Since ball speed variation entails a condition of ball acceleration which can produce instantaneous ball skidding and race wear, a reduction in ball diameter will minimize this adverse effect by reducing ball moment of inertia and weight. Considering that inertia varies as d^5, weight varies as d^3, and capacity varies as d^2 (approximately), a small reduction of ball diameter can cause considerable reduction in ball skidding with only a small reduction in bearing capacity.

Operation under both light and varying thrust loads as well as varying inner ring speed can also cause ball speed variations, and reduction in ball diameter from the size determined by pure capacity considerations can be of help.

The number of balls of a given size which a bearing can contain depends largely upon cage strength considerations. A one-piece cage construction permits more balls to be employed than a two-piece cage because the absence of rivets or other fastening devices enables the one-piece cage to be designed with less space between the balls.

The factor which contributes most to increasing

bearing capacity is the ball diameter d rather than the number of balls n, as brought out by the fact that capacity varies as d^2 and only as $n^{2/3}$.

Some of the factors to be considered in arriving at optimum race curvatures for high-speed bearings have already been discussed. An additional point to be considered is the type of loading to which a bearing is subjected.

Ball speed variation can be reduced by increasing the race curvatures. This will reduce the contact angle variation and consequently the ball speed variation. The smaller contact ellipse resulting from wider curvatures will also cause a reduction in heat generation, although at the expense of bearing capacity.

Another method of reducing the effect of ball speed variation is to increase the thrust to radial load ratio. With more thrust, contact angles of the balls around the bearing periphery tend to become more nearly equal.

Contact angle to be employed in a high-speed bearing is dictated to a great extent by relative rotative motion about the Z axis. In general, a high-speed bearing should be designed with as small a contact angle as thrust capacity and internal clearance considerations permit.

Methods presently used to evaluate the life of a high-speed bearing are based in part on conventional fatigue considerations, primarily to determine whether the loading imposed is within the range of capacity required, and on the speed and type of loading involved, mostly on a qualitative comparison with designs having given successful performance in high-speed applications.

It is recognized that the presently used capacity formula is inadequate in predicting the life of a high-speed bearing because it is based purely on the classical concept of fatigue of the rolling elements and does not take into account the aforementioned high-speed effects. Considerable effort is now being expended to develop more realistic methods of predicting the life of high-speed bearings.

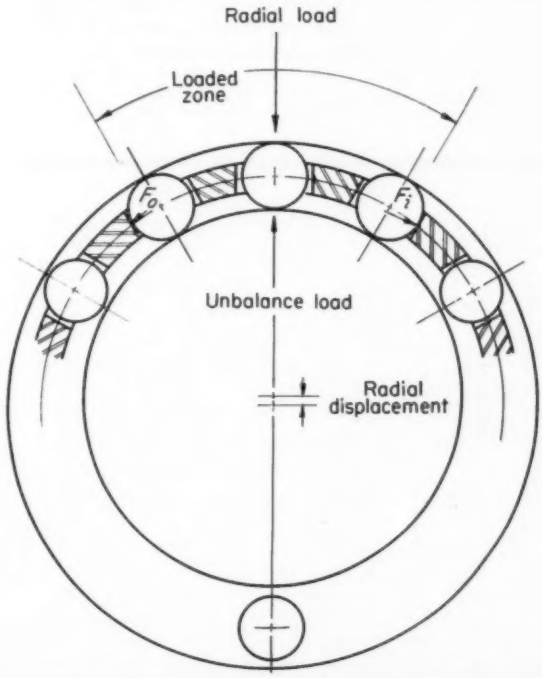

Fig. 14—Forces exerted on the separator by balls entering and leaving the loaded zone of a bearing. Separator is in tension, since entering force F_i exerted by ball is opposed by force F_o exerted on leaving zone.

Separator Design

Basic Requirements: Experience to date has shown that a separator or cage is needed to space the balls in a high-speed bearing. Design of such cages can be very critical. The following basic cage design philosophy has been evolved partly as a result of operating experience and partly as a result of theoretical considerations.

Cages for high-speed bearings should have:

1. Minimum weight.
2. Minimum moment of inertia.
3. Sufficient structural strength.
4. Ball pocket and land control surfaces designed for minimum wear.
5. Material having low coefficient of friction.
6. Material with high coefficient of heat transfer.
7. Material having thermal coefficient of expansion as equal as possible to that of bearing ring and ball materials.
8. Minimum area to restrict lubricant flow through bearing.
9. Configuration to enhance adequate bearing lubrication.

Minimum cage weight will cause minimum centrifugal loading against inner or outer race guide surfaces and reduce the moment of inertia of the cage. Minimum cage moment of inertia reduces the tendency of the balls to skid in high-speed bearings operating under conditions of acceleration and deceleration.

Cages must have sufficient structural strength to withstand the forces encountered in high-speed bearing operation—those exerted by the balls in the ball pockets, and those exerted on the control surfaces. When a bearing is subjected to radial loading, the centers of the inner and outer rings are displaced radially, causing an approach of these races in the zone in which the radial load acts. Since the clearance between the races is at a minimum in this loaded zone, a certain force is required to pull the balls into it. This force is provided by the balls in the loaded zone acting on the separator ball pockets. These forces tend to fail cages in circumferential tension, Fig. 14, and cause ball-pocket

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and control-surface wear.

These forces are present when a bearing is subjected to stationary radial loads as well as rotating radial loads with the exception that the cage is subjected to a larger number of stress cycles per revolution than under stationary loading.

Under combined loading, a condition of ball speed variation exists where balls begin to crowd one another, resulting in additional forces on the separator ball pockets and land riding surfaces.

The centrifugal force effect of the inherent unbalance of a high-speed cage produces a circumferential tension as well as wear forces against the control surfaces.

The cage must prossess sufficient structural rigidity so excessive deflection under all of the above load conditions does not occur. However, it would be impractical to design a cage strong enough to cope with forces that arise as a result of conditions of severe unbalance, misalignment or loss of interial bearing clearance. Every effort should be made to avoid such conditions in high-speed bearings.

Normal wear in a separator occurs in the ball pockets and on the control surfaces contacting either the outer or inner ring. Through careful attention to ball pocket geometry and suitable construction of the land riding surfaces, depending on the type of lubrication to be employed, separator wear can be minimized.

Since lubrication of the separator control surfaces is essentially "thin film" at best and probably mostly "boundary," it becomes important that the separator material have minimum coefficient of friction and galling tendency. The boundary lubrication film is formed by a chemical reaction between bearing metal and lubricant. Thus, selection of the best metal and lubricant combination becomes very important.

It is desirable to have cage materials with the highest possible coefficient of heat transfer to enable maximum heat to be conducted from the balls and ring control surfaces to the lubricant and ambient air. It is also desirable to have the thermal coefficient of expansion of the cage material as close as possible to that of the ring and ball material to minimize changes in the original operating clearances. This is of particular importance when outer ring riding cages are employed.

It is generally desirable to have the maximum possible surface area of the rolling elements exposed to lubricant flow. It, therefore, becomes necessary to use separators causing minimum obstruction to lubricant flow to the rolling elements, and it is further desirable to use separators that will act to promote the lubricant flow to these surfaces.

Design of cages for high-speed bearings, therefore, becomes a compromise between the basic design parameters stated at the beginning of this section to arrive at a bearing specifically suited for the application. Factors which must be taken into account are the type of loading imposed on the bearing, housing and mounting construction, operating temperatures, and the method, type and available amount of lubrication.

High-speed cages are generally guided on either the inner or outer ring, and the portion of the ball pocket contacting the ball is essentially straight, permitting radial displacement of the cage.

Effect of Bearing Size: Sufficient difference in requirements and operating characteristics exist to break the problem of cage design into two basic groups: (1) cages for small bearings and (2) cages for large bearings.

SMALL BEARINGS: Small bearings in the 8 to 20-mm bore range are often employed to support small high-speed turbines driving accessory equipment. These can again be subdivided into two basic categories. Referring to the design parameters previously noted, these categories are:

1. Bearings subjected to heavy radial, vibratory and unbalanced loading. In such cases, design parameter 1 must be compromised to meet parameter 3, thereby compromising parameters 8 and 9 as well as 2. Quite often item 4 cannot be fully met under those conditions but parameters 5, 6 and 7 are not affected.
2. Bearings which must perform with a minimum amount of lubrication under minimum radial, vibratory and unbalanced loading. The maximum emphasis under these operating conditions is on design parameters 8 and 9. Since the separators in such applications are subjected to very little loading, they can be designed with less strength, parameter 3, than bearings in the previously mentioned group, thereby meeting requirement 1 and 2. Parameters 5, 6 and 7 are, as before, essentially unaffected.

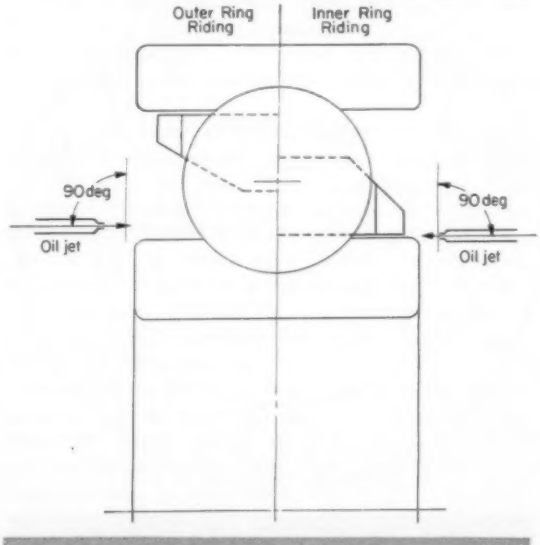

Fig. 15—Lubricating outer and inner ring riding ball-bearing cages with oil jets. More room is available for oil injection on outer ring riding cages.

LARGE BEARINGS: In general, cages for large high-speed bearings are not as critical as those for small high-speed bearings and are usually less frequently the cause of bearing malfunction.

Design parameters 1 and 2 are important in that cage weight and moment of inertia may very seriously affect such factors as ball skidding on raceways during high accelerations. Parameters 3 through 7 are all of great importance, while items 8 and 9 are of lesser importance here than in small bearings.

In view of the relatively large separator weight and size it becomes necessary to keep inherent separator unbalance to a minimum.

Effect of Lubrication: Function of the oil is to prevent metallic contact of the rolling elements of the bearings and to carry away self-generated and externally created heat. The majority of high-speed bearings are oil lubricated, either by oil splash, oil jet, oil mist or fog, or wick feeding. These lubrication systems can be either of the one-shot, nonrecirculating or of the recirculating type.

Oil jets should be directed at right angles to the bearing face and impinge at the clearance between separator bore and inner ring OD in both inner and outer ring riding cage bearings, Fig. 15. The increased clearance between separator bore and inner ring OD in the outer ring riding cage facilitates easier and more efficient injection of oil into the bearing.

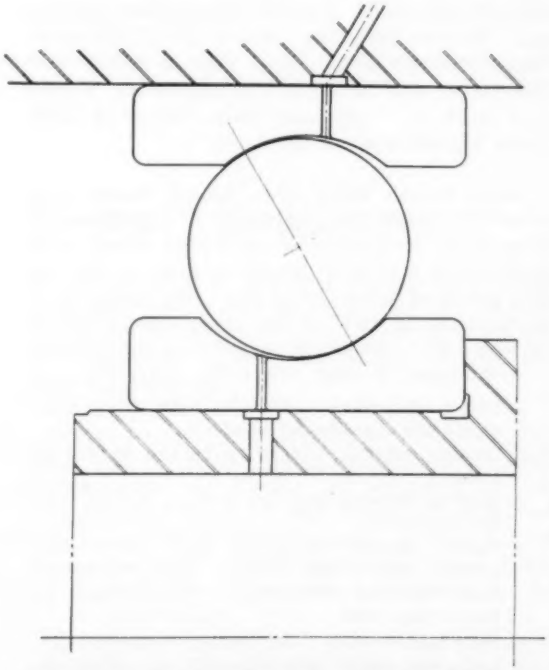

Fig. 16—Method of introducing oil through outer and inner raceways.

Oil can also be introduced through holes in either inner or outer rings, Fig. 16, assuring maximum utilization of the available oil supply. This is of particular importance in applications where a limited amount of oil is available.

Centrifugal force action and the inherent scant lubrication condition of the high-speed inner race make it desirable to introduce the oil through the inner ring. This is more difficult to accomplish in view of the problem of introducing oil into a high-speed shaft.

Oil fog or mist lubrication can be accomplished by injecting through a jet or orifice, or by wick systems. Mist or fog lubrication has been found to be the most effective method of oil lubricating small bearings. Large bearings can be lubricated best with oil jets.

While no exact line of demarcation exists, it has generally been found in high speed applications that bearings larger than 2 or 3 bore (15 or 17 mm) are most successfully lubricated with oil jets, and bearings below this size, with air-oil-mist.

One reason is that the small quantity of oil required by small bearings would require very small nozzle orifices for jet lubrication, which would create a problem from the standpoint of metering and nozzle clogging. Furthermore, the finely dispersed oil particles in air mist can more easily penetrate through the high "windage block" effect of a small bearing rotating at high speeds and lubricate the rolling elements. The impinging of a high-velocity oil jet necessary to penetrate the "windage block" would cause excessive internal heating and possible damage to the cage.

As bearing size increases, larger quantities of oil are required, making jet lubrication more practical.

In many applications, particularly in small accessory units, it is advantageous from an installation and overall design complexity standpoint to lubricate bearings with grease.

The upper speed limit for conventional grease-lubricated bearings is in the neighborhood of 300,000 *DN*. It has been found that by resorting to outer ring riding cages this operating limit could be extended to over 600,000 *DN*, and some short-run testing at 1 million *DN* has been accomplished.

As previously discussed, the two points of contact in a cage requiring lubrication are the ball pockets and control surfaces.

At high speeds, centrifugal force throws the grease away from the inner ring toward the outer ring. This action prevents sufficient grease from entering the clearance between inner ring OD and the bore of an inner ring riding separator, causing scoring of these surfaces with resultant cage and bearing failure.

However, considerably better performance is obtained when outer ring riding cages are employed, partly because the centrifugal force throws the lubricant outward and adequately lubricates the

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outer ring riding control surface, and partly because of other effects not yet fully understood but believed to fall into the category of design parameter 9: "configuration to enhance adequate bearing lubrication."

Past experience on bearings operating in the conventional speed range with grease lubrication has shown that bearing life, limiting speed and load-carrying ability will be less than when oil lubrication is employed. Grease does not afford a bearing the same benefits of lubrication as oil, and the design of a grease-lubricated bearing becomes much more critical from the standpoint of clearances, configuration and choice of cage material.

Based on the information gained to date, and the previous considerations, it appears that the benefits derived from the use of an outer ring riding cage with grease lubrication would also hold with oil lubrication.

Inner ring riding cages do work satisfactorily at high speeds with oil lubrication, at *DN* values to 1×10^6 for small bearings and 1.5×10^6 for large bearings. This is due mostly to the greater quantity and fluidity of this type of lubricant, making the overall lubrication problem much less critical than with grease lubrication. As operating speeds are increased, the trend is toward the use of outer ring riding cages, particularly in small bearings.

Cage Materials: High-speed cages are usually made of pressed metal or are machined from solid stock.

In the pressed-metal form, bronze-clad SAE 1010 steel and Grade A phosphor bronze have been successfully employed to temperatures of 400 F.

In the machined types, phenolic is still considered to be the best type of material for high-speed cages. It has the ability to operate successfully with minimum of lubrication, but its upper temperature limit of 300 F severely restricts its use in applications such as gas turbines.

Bearings containing phenolic cages have been successfully applied in many high speed applications at *DN* values of about 1×10^6. However, the structural strength of this material, which reduces rapidly as the 300 F point is reached, provides another upper limit on its usage.

Iron-silicon bronze has been found to have higher strength and comparatively good antigall characteristics, and has been employed at temperatures to 400 F. Beyond this point, it begins to lose its strength.

For cages required to operate above 400 F, the best material found to date appears to be nickel-oxide-treated S-Monel, which has been found to have essentially a constant coefficient of friction at room and elevated temperatures, as well as the necessary high temperature strength. The nickel-oxide coating reduces gall characteristics during the run-in period.

Both silver-plated and nonsilver-plated iron-silicon bronze cages have been tested. In preliminary investigations, it has been found that silver plating may have a tendency to reduce the initial operating temperature of a bearing. However, once a bearing is properly run in, no particular advantage could be noted. It was also found that silver has a high coefficient of friction and will gall excessively at temperatures above 400 F.

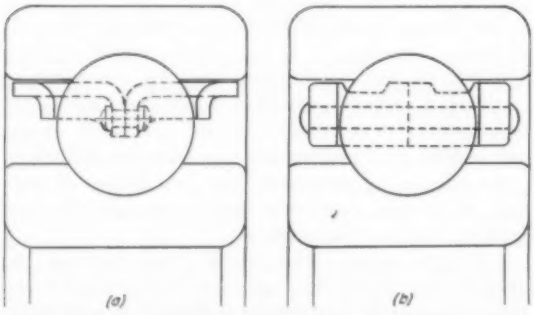

Fig. 17—Two-piece cages for conventional deep-groove bearings used at high speeds; *a*, pressed metal (WD) cage, and *b*, machined iron-silicon bronze cage.

Cages for High-Speed and Ultrahigh-Speed Bearings: At present a bearing operating above 500,000 *DN* is considered to be a high-speed bearing, and a bearing operating above 1 million *DN* an ultrahigh-speed bearing. These lines of demarcation have been arrived at by experience and usually as a result of a given cage design becoming inadequate beyond a given speed range.

Inner Versus Outer Ring Riding Cages: Considerable theoretical and practical experience indicates the desirability of outer ring riding cages. However, it may be of benefit to describe the relative merits of inner versus outer ring riding cages, particularly in view of the controversial manner in which this problem is regarded in the industry.

Advantages of outer ring riding cages are:

1. Better lubrication is afforded both rolling elements and cage control surfaces.
2. Relative rubbing velocity on control surface is lower.
3. Bearing pressure per unit area on control surface is lower.
4. Control surface contacting cooler outer ring permits easier heat removal from separator. Inner ring controlled separator is fed heat from hotter inner ring.
5. Introduction of oil into bearing is easier.
6. Lubricant can be directed more successfully at inner ring which in high-speed bearings tends to be lubrication-starved.

Disadvantages of outer ring riding cages are:

1. Mass moment of inertia and weight are higher.
2. Strength-weight ratio is lower.
3. Careful attention must be given to clearance between separator OD and outer ring bore in

bearings operating at elevated temperatures to avoid possibility of seizure due to different expansion rates.

High-Speed Cages: Conventional deep-groove bearings are employed successfully at *DN* values of up to 1 million with either an outer ring controlled, two-piece pressed-metal cage or WD type, Fig. 17*a*, and a machined iron-silicon bronze cage, Fig. 17*b*—both with oil and grease lubrication.

The WD type is lighter, has a certain degree of flexibility to adapt to ball speed variations and, once dies have been designed, can be more readily produced.

The machined cage can be produced without considerable initial die outlay, but the precision machining required, particularly in small sizes, does not lend this cage to mass production to the same degree as the WD type.

Ultrahigh-Speed Cages: At speeds above *DN* of 1 million—particularly in small bearings—cages of one-piece configuration are employed. This is made possible by the use of bearings having one low shoulder on the inner ring, Fig. 18.

This type of cage can be completely manufactured and inspected prior to assembly into the bearing. This is not possible with the two-piece rivet-assembled type. Degree of accuracy of this type of cage is commensurate with the requirements of an ultrahigh-speed bearing.

Elimination of the rivets permits cage construction to satisfy better the high-speed separator design parameters 1, 2, 3, 4, 8 and 9. The same advantages of pressed metal versus machined cages hold for these two configurations as in the two-piece high-speed cages.

Bearing Configuration

Two special bearing configurations have so far come into prominence in high-speed applications. These are the deep-groove type with one low inner ring shoulder, known as the J-type, and the split inner ring bearing.

J-Type Bearing: This bearing configuration, Fig. 19, is basically similar to the conventional angular-contact type except that its nonthrust or low shoulder is on the inner ring. As in a conventional angular-contact bearing, advantages such as the use of a one-piece cage, larger and more balls, and higher thrust shoulders are realized in the J-type construction.

Two factors make this type of construction a good choice for an ultrahigh-speed bearing:

1. Absence of a low outer ring shoulder permits an outer ring riding cage to be supported on two lands.
2. The J configuration conforms to the geometrical rearrangement which occurs in a high-speed ball bearing.

At high speeds, the outer race contact angle approaches zero and the inner race contact angle increases.

The double-shouldered outer race avoids the danger inherent in a conventional angular-contact bearing of the balls approaching the counterbored antithrust shoulder. Momentary thrust reversal due to inertia or vibratory loading has been known to cause rapid failure of conventional angular-contact bearings operating at high speeds.

Since the inner race contact angle increases in a bearing operating at high speeds, the possibility of the balls being damaged by hitting the low shoulder on the inner ring is much less.

This type of bearing can take thrust in one direction only and is often furnished with the ring faces on the low shoulder side ground flush within 0.0001 or 0.0002-in. for "reversible thrust" mountings.

Split Inner Ring Bearing: A split inner ring bearing, Fig. 20, has an inner ring of two halves and is, in a sense, a logical extension of the J-type bearing using a one-piece cage. It can carry thrust in either direction and should be predominantly thrust loaded.

Capacity within a given space envelope can be increased when resorting to the split inner ring configuration because larger and more balls can be assembled into the bearing, and higher race shoulders can be employed.

This type of bearing is completely separable since the two inner ring halves come apart. The balls are permanently retained in the separator ball pockets, thus making a subassembly which is removable from the outer ring. This facilitates bearing cleaning and inspection as well as assembly.

Within certain limits, radial play can be varied independently of the endplay. This factor is important when close axial clearances must be main-

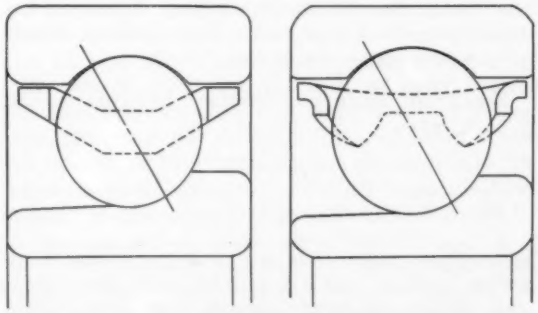

Fig. 18—One-piece cage constructions for small high-speed bearings. These are used with bearings having one low shoulder on the inner ring.

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tained (thus keeping bearing endplay to a minimum) with maximum radial clearance to allow for temperature differentials between inner and outer rings and balls in high-speed, high-temperature operation.

The inner race is of Gothic arch construction having a race radius overlap, Fig. 20. This is accomplished by generating the race to radius r_i with a shim of thickness t clamped between the two halves. After grinding, the shim is removed. When the two inner ring halves are clamped together, a race radius overlap equal to t will result.

Internal clearances of ball bearings, both axial and radial, depend upon ball diameter d, race radii r_i and r_o, and their tolerances. In a split inner ring bearing, the shim thickness t becomes an additional variable which considerably complicates the geometric relationships.

While in general the same choice and limitations of contact angles, race curvatures, ball diameters and other parameters apply, one additional factor peculiar to the split inner ring bearing only, and vital to its successful application, must be considered.

When no external thrust is applied to the split inner ring bearing, the ball will come to rest on the two inner races at contact angle β_r. This is also the case when pure radial load is applied, except that the outer raceway will then contact the ball, making a three-point ball contact in the loaded zone.

Based on the previous analysis of rolling and nonrolling of balls in nonradial positions, the degree of sliding on the contact ellipses at both inner race halves could be considerable if the bearing were operated under pure radial load at high speed. Operation under pure radial load is, therefore, limited to low bearing speeds only.

When an external thrust load is applied, a condition of two-point contact at angle β exists much the same as in a conventional bearing. However, if $\beta_r > \beta$ the ball will continue to contact the nonthrust race, and three-point ball contact will exist. Mathematical analysis has shown that certain adverse conditions of tolerance stack-up and values of race radii, shim thickness, contact angles and internal clearances can create the condition where $\beta_r > \beta$ even under pure thrust.

Nonthrust inner race contact is avoided, and $\beta > \beta_r$, when

$$\frac{P_d}{2\,Bd} + \sqrt{1 - \frac{t^2}{(2r_i - d)^2}} > 1 \qquad (2)$$

where P_d = radial clearance of an equivalent deep-groove bearing; and B is defined as for Equation 1. This design parameter imposes additional limitations on the choice of optimum race curvatures and contact angles, considerably complicating the "design compromise" process.

It has been found that prolonged operation under conditions of nonthrust wiping will cause overheating of the nonthrust raceway, which can lead to early bearing failure. This situation is particularly critical when three-point contact occurs

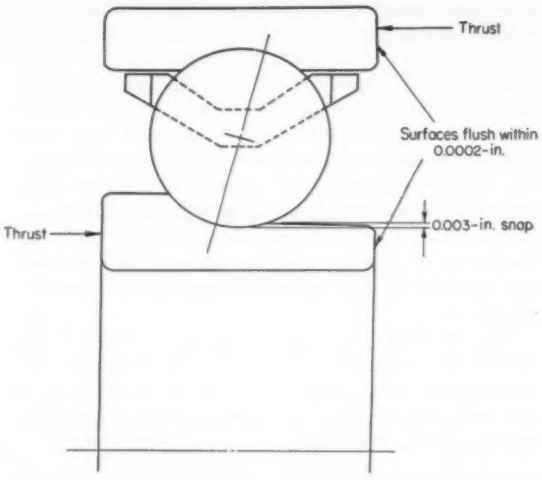

Fig. 19—Ultrahigh-speed "J type" bearing. Similar to an angular-contact bearing, its nonthrust low shoulder is on the inner ring.

only part of the time, i.e., when β is only slightly less than β_r. At each instance of contact with the nonthrust raceway, the axis of ball rotation will shift, inducing additional sliding at all contact points. A very similar condition exists when such a bearing is subjected to combined loading with a predominant radial load.

At high-speed operation, β increases to β_i giving an additional safety factor. However, analysis, field experience, and manufacturing considerations have dictated the design practice which requires β to exceed β_r by at least 6 deg under a nominal gage load.

The previous considerations are for split inner ring bearings supporting thrust loads only. While this type of bearing is basically a thrust bearing, a certain amount of radial load in combination with thrust load can be supported.

It is possible to determine how much radial load a split inner ring bearing can support without suffering three-point contact under a given condition of speed and thrust load. This determination is complicated and will only hold for one condition of operation. It actually becomes necessary to plot a series of curves of thrust load versus radial load at different bearing speeds which will result in two-point ball contact. As a general preliminary design approach, a split inner ring bearing should be subjected to a continuous thrust load of at least five times the continuous radial load.

However, it is difficult to prevent momentary three-point contact when split inner ring bearings are subjected to momentarily heavy radial loads, such as in jet engines as a result of the high gyratory forces created during airplane maneuvers. Although no serious adverse effects have as yet

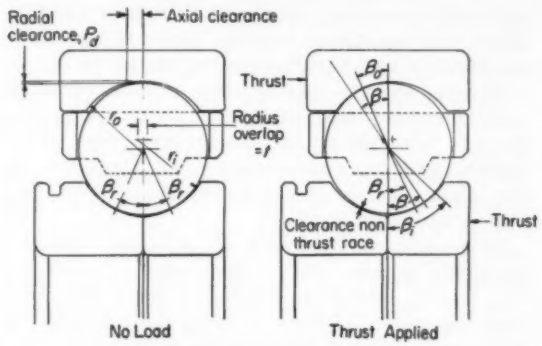

Fig. 20—Split inner ring bearing, another high-speed ball bearing, used under primarily thrust loads.

been reported in this application, it may ultimately become necessary to increase the thrust loading momentarily, either by application of springs or pneumatic loading. Similar precautions may become necessary during high-altitude operation where thrust loads on the jet-engine main shaft bearings drop rapidly while the radial loads remain constant.

As thrust loading exceeds the capacity of a single split inner ring bearing, matched sets of two bearings can be employed, Fig. 21. To utilize each bearing's capacity to the fullest, the set is carefully matched to carry thrust loading as equally as possible. To accomplish this:

1. Bores of all four inner ring halves are held within 0.0002-in. or better.
2. OD's are matched within 0.0002-in. or better.
3. The inner and outer ring faces on the abutting sides of the bearings are ground flush within 0.0002-in. or better under the approximate operating thrust load. In this manner, an approximately equal thrust load distribution is achieved under either the maximum thrust load or under the load most frequently applied. The variation in contact angles caused by the stack-up of race curvature and ball diameter tolerances results in two distinct deflection curves for the two bearings in each set, Fig. 22. The intersection of these two curves represents the point of equal load distribution.
4. Contact angles are held within 2 deg or better per set. To benefit from this precision, careful attention must be given to the mounting so both bearings will have the same contact angles in operation, thus assuring equal thrust load distribution.

Shaft and housing tolerances must be such that all the inner rings are mounted with equal press fits on the shaft and all the outer rings to the same degree of looseness in the housing. Radial deflection of shaft and housing seats must be equal at both bearings, again to assure that the final mounting fits of both bearings are equal.

Lubrication and cooling of both bearings must assure equal operating temperatures so that the internal bearing clearances remain equal. If the two bearings operate at different temperatures, as a result of unequal amounts of oil passing through them, the thrust load distribution is destroyed. Often more than one oil jet on one or the other of the two bearings must be applied, because bearings in such a set appear to "pump" oil at unequal rates, depending on the direction of thrust load application and upon the method of oil introduction.

It therefore becomes necessary in the development of a tandem mounting to adjust the oil supply, amount as well as direction, by actual test experience based on bearing operating temperature under given conditions of speed and load.

Thrust load distribution in bearings properly mounted can vary from the theoretically equal value under the "stickout load" to a 40-60 per cent distribution at lower loads. Production bearings have been measured to give a distribution of 47.5-52.5 per cent.

Materials and Temperatures

Rings of standard bearings are usually manufactured of 52100 and balls of 51100 steel. When properly stabilized, bearings of such steel can be operated at temperatures to 400 F and in special lightly loaded applications at somewhat higher temperatures for brief periods.

Bearings receiving this maximum stabilization suffer approximately 20 per cent reduction in capacity, at a minimum hardness of 58 Rockwell C. For operation at higher temperatures, it becomes necessary to resort to the use of tool steels.

Medium-high-temperature tool steels retain 58 Rockwell C hardness to 700 F, while molybdenum and tungsten tool steels will retain the same hardness to 1100 F. Tool steel is sometimes employed in applications where 400 F temperatures are not exceeded. The 20 per cent capacity reduction which a 52100 steel bearing would suffer when stabilized for maximum temperature operation is thereby avoided.

Due to the inherent lack of cleanliness of commercially available tool steels as compared to that of commercially available 52100 steel, tool steel bearings have exhibited a marked lack of reliability. This manifests itself in an erratic fatigue failure pattern with high incidence of early bearing failures, as compared to the 10 per cent failure life computed (B-10 life). This situation is believed due to the large amount of nonmetallic inclusions, oxide stringers, and other impurities contained in conventionally air-melted tool steels.

One method of producing a cleaner steel is to melt in a controlled or vacuum atmosphere. Bearings of both vacuum-melted tool steel and 52100, with the steel metallurgically inspected to meet special requirements of cleanliness, have been fatigue tested under controlled laboratory conditions. The tool-steel bearings have been operated at 400 F with MIL-L-7808B oil, and the 52100 bearings have been operated at 130 F using petroleum-base oil.

Results on several hundred bearings made of both types of vacuum-melted steels have revealed a significant improvement in (1) reduction of

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early bearing failures, and (2) increase of average bearing life over bearings made from air-melted steels. This improvement was essentially equal for both types of vacuum-melted steels. The B-10 life was increased by approximately four times and the average life by approximately twice the calculated catalog life.

This improvement represents a very important development in bearing manufacture, and is of particular interest to the aircraft industry where reduction of early failures is of vital importance. Research work is now in progress to determine what other factors besides cleanliness of the steel could possibly cause this improvement in bearing fatigue life.

Testing of 140-mm bore jet-engine mainshaft bearings made of vacuum-melted 52100 steel has corroborated the laboratory results. These bearings were tested at 1.4×10^6 *DN* and high thrust loading.

Lubrication

At present, oils and greases are available that are thermally stable and have antioxidation characteristics up to 450 F. However, most of these do not have the necessary load-carrying capacity required to lubricate the rolling elements adequately in a high-speed ball bearing. Furthermore, the lubricants are usually of limited viscosity range, not capable of meeting either the low-temperature or high-temperature requirements.

For the service life required in ball bearings, petroleum-base lubricants can usually not be employed above 300 F, and cannot meet the −65 F low-temperature requirements often imposed. At the high temperature, petroleum oils have very high evaporation rates.

Silicone-based lubricants are available that are thermally stable between the range of −65 and 400 F, and −40 F to 450 F, but have poor load-carrying capacity. Work is being done to improve their load-carrying and thermal stability.

Diester-based lubricants with fair load-carrying characteristics are available that will function in the range of −65 to 400 F. Work is in progress to develop fluorinated diester compounds having higher thermal stability.

Development work is also in progress on solid and gas lubrication in the 700 to 1000 F temperature range. Bearings lubricated with fine-particle molybdenum disulfide at temperatures to 700 F and with graphite at temperatures to 1000 F have been operated in the laboratory.

Bearing capacity, as usually referred to in present day catalogs, is based on performance with conventional petroleum-base lubricants. Use of synthetic, solid or gas lubrication at the elevated temperatures may considerably change this picture to the point where conventional bearing fatigue life is no longer a useable criterion. At this stage, shorter overall bearing life even under light loading and speed may have to be accepted.

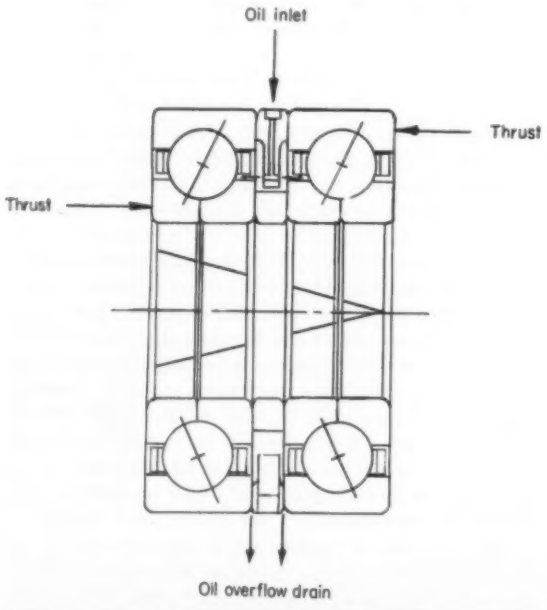

Fig. 21—Matched set of two split inner ring bearings, used where thrust loading exceeds the capacity of a single bearing.

Mounting Methods

Very careful attention must be given to the mounting, installation and choice of bearing fit-up in applications where high-speed and high-temperature operation is required.

Mounting Fits and Internal Bearing Clearance: Generally, high-speed bearings are mounted with a slight interference fit on the shaft and a loose fit in the housing. The amount varies with specific bearing size and should be developed to suit the particular application. For example, small bearings as used in turbo accessory applications, are mounted zero to 0.0002-in. tight on the shaft and 0.0001 to 0.0003-in. loose in the housing. Loose housing fits permit axial bearing movement which is necessary with preload-spring installations.

Large bearings, which are more heavily loaded, usually require heavier shaft press fits to prevent excessive rotation of the bearing's inner ring on the shaft. However, care must be exercised not to stretch the inner ring to the point where circumferential stresses are set up in the raceway which will adversely affect bearing life. Inner rings of high-speed bearings should be axially clamped

against the shaft shoulders.

In small bearings operating at ultrahigh speeds, 1.2×10^6 *DN* and higher, it becomes necessary to investigate the reduction of inner ring press fits as a result of circumferential expansion. A possible reduction of internal bearing clearance should also be considered at these speeds.

For successful operation, a small high-speed bearing must be made with a larger than normal internal clearance to prevent seizing or radial preloading of parts. This has been found from experience. One of the reasons is that high speeds cause higher self-induced operating temperatures within the bearing. These tend to expand the rolling elements and reduce the radial clearance originally built in. Other factors not yet fully understood are also believed to warrant the use of looser internal fit-ups.

Since radial clearance is critical in a high-speed bearing, it must be controlled when mounting a bearing. This can be done by selective shaft and housing assembly so that the degree of interference is balanced with the particular radial play range of the bearing, making the criterion for a successful installation the final mounted internal radial clearance.

Bearings can be procured with bore, OD and radial clearance classified to the nearest 0.0001-in. and marked on the container. For example, a 10-mm bore bearing having a radial play range of 0.0008 to 0.0011-in. is mounted 0.0001 to 0.0003-in. tight on the shaft and 0.0001 to 0.0003-in. loose in the housing. Assuming approximately 80 per cent of the press fit to cause reduction of internal bearing clearance, by proper selection of parts a minimum radial play of 0.0007-in. can be maintained.

When bearings are operated at high temperatures, or through a large temperature range, mounting fits must be re-evaluated to take into account the different thermal expansion rates of shaft, bearing, and housing material. In extreme cases, it may even become necessary to make all three parts of identical material. Light-alloy housings should not be employed in applications having a temperature range greater than 175 F unless steel liners are used.

In design of bearing mountings for applications required to operate under variable temperature, particular attention should be given to bearing internal clearance and mounting fits. Housings are very often cooled at a different rate (such as caused by varying altitude), while shafts continue to receive essentially a constant supply of heat. This has been known to cause bearing seizure.

Eccentricity: Small bearings of ABEC grade 5 have 0.00015 to 0.0003-in. eccentricities between bore and inner ball race. It is desirable to follow the practice of the machine-tool industry and to line up the high points of eccentricities of the inner rings in high-speed applications. This causes the shaft to whirl essentially parallel to the axis of rotation, giving a maximum shaft and wheel excursion equal to the eccentricity.

If this practice is not followed, two bearings might be mounted with the inner ring high points of eccentricities at 180 deg to each other. The shaft centerline would then be at an angle with the axis of rotation, and whirling at a radius considerably greater than that of the race eccentricities would result.

Balancing: To perform successfully, a high-speed unit such as a turbo accessory mounting must be balanced to a high degree. This will minimize the unbalanced radial load on the bearings, previously described as being more harmful for bearings than a steady radial load.

Degree of balance necessary depends on the bearing size and speed under consideration. For example, a 10-mm bore bearing operating at 100,000 rpm will have a 5 lb unbalance load when the assembly is balanced to 0.0005-oz-in.

Since the unbalanced forces depend on the square of the speed, it becomes obvious that balancing small bearing assemblies operating at high speed is of much more critical importance than balancing large bearing assemblies operating slowly.

High-speed rotating assemblies are very often operated in a speed range between the first and second critical speeds. In such cases, the rotating assembly should be balanced within the speed range corresponding to the interval between first and second critical speeds. An elastic rotating assembly dynamically balanced in one mode of vibration or critical speed range is not necessarily dynamically balanced in another mode of vibration.

Preloading: High-speed bearings should not be

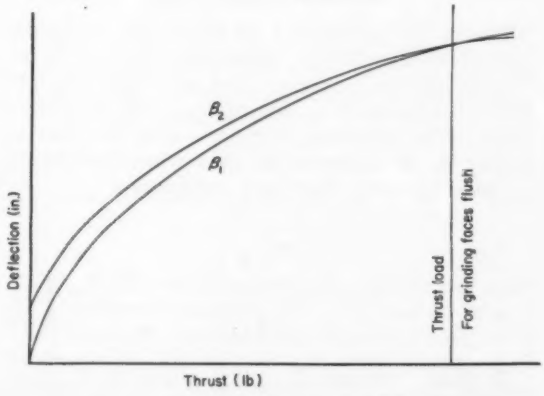

Fig. 22—Deflection curves for a tandem set of split inner ring ball bearings. Intersection of the two curves is the point where load is equal on each bearing.

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operated without the benefit of thrust loading. In designing a bearing mounting for high-speed operation, the thrust load should be large enough to keep the balls as near the original mounted contact angle as possible during high-speed operation and to provide sufficient load to keep the balls from "skidding" under rapid acceleration or speed fluctuations.

In many instances, only the thrust-carrying bearing will have enough external thrust on it to be of benefit. It then becomes necessary to incorporate a preload spring to suitably thrust load the mating bearing and to provide the necessary load during start-up where external thrust loading is negligible. The thrust load necessary can be computed but the computation requires exact knowledge of the bearing's internal geometry. It should be part of the bearing manufacturer's recommendation for a specific application.

Bearing Failures

The previous sections dealing with design and installation have as their basic objective successful bearing operation. If any one of these design concepts mentioned are violated, premature malfunctioning of high-speed ball bearings may be the result. It might be well to summarize typical causes of bearing failure:

1. Lack of adequate lubrication of the rolling elements, through
   a. Inability of lubricant to gain access to the rolling elements.
   b. Inadequacy of the lubricant itself.
   c. Adverse ambient operating conditions.
2. Temperature differential between bearing elements.
3. Excessive unbalance and vibration.
4. Excessive operating and ambient temperatures.
5. Excessive bearing loading.
6. Ball skidding.
7. Improper mounting and maltreatment of bearing prior to installation.
8. Thrust reversal at high speed.
9. High acceleration.

Reasons 1, 2 and 3 are the most frequent causes of failure in small bearings, while large bearings most frequently fail because of factors 4, 5 and 6.

Items 4 and 5 are not usually a frequently found cause of small bearing failure, primarily because these bearings can rarely be run long enough to experience a "classical" fatigue failure, and are not usually subjected to excessively high operating temperatures.

Small bearings are more sensitive to factors 7, 8 and 9 than large bearings, and item 6 is, of course, a constant source of failure in all sizes of bearings. However, at this time it is thought to be more detrimental in large bearings.

In general, cage failures are predominant in small high-speed bearings and rolling element spalls in large high-speed bearings.

Tips and Techniques

Nameplate Lettering

Designing a nameplate can be a time-consuming, tedious task entailing large-scale layouts to arrive at proper character size and spacing. The method detailed here can eliminate much of this effort. The following formulas give the correct height, h, of letter to be used when line length or lettering area have been determined.

$$h = K \frac{L}{N_L}$$

$$h = C\sqrt{\frac{A}{N_T}}$$

In these formulas, L = line length for N_L characters, in.; A = area for N_T characters, sq in.; h = character height, in.; K and C are constants for a given letter style (see table), with $C = (2K/3)^{1/2}$. The formulas are based upon spacing between lines of one-half character height and spacing between words, initials and sentences of one character height. Another factor to be considered is that the formulas are based upon solid engravings. When loose type in interchangeable holders is used, manufacturer's catalogs should be consulted for spacing.—HAROLD BELOFSKY, *Bronx, N. Y.*

Type Style	Character Width, Average (in.)	K	C
Standard Gothic	0.66h	1.0	0.82
Extra Condensed	0.3h	2.2	1.2
Condensed	0.4h	1.7	1.1
Medium Condensed	0.5h	1.3	0.93
Medium Extended	0.8h	0.83	0.75
Extended	1.0h	0.67	0.67
Extra Extended	1.5h	0.45	0.55

Changing Ammonia Prints

When changes on brownline intermediate prints made on any type of ammonia developing machine are necessary, this technique will produce sharper reprints. Instead of using the eradicator first and then drawing in the required change, do the opposite. That is, first draw the required change in pencil and then eradicate the parts to be eliminated.—MAX SHELDON, *chief draftsman, Acme Electric Corp., Cuba, N. Y.*

Some methods for **Making Hydraulic Circuits Safe**

For **Men**
Machines
Materials

By H. L. Stewart and J. M. Moritz
Logansport, Ind.

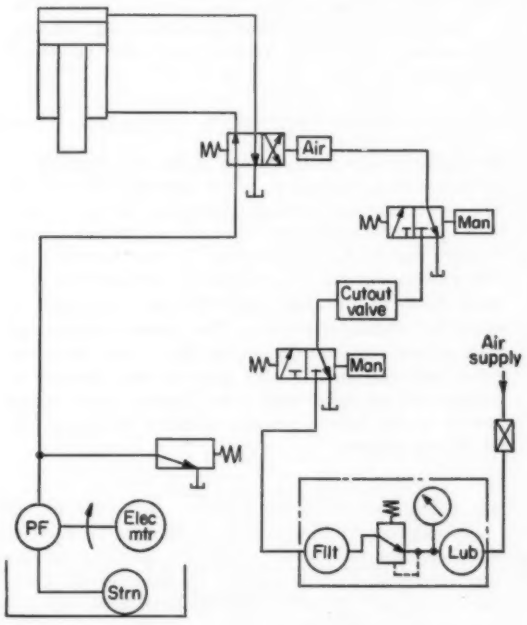

Fig. 1—Nontie-down circuits prevents a machine operator from tying down one of the two controls intended to require two-hand operation. In this circuit, used on a tube-sizing press, the cutout valve between the two manually operated, three-way valves provides the nontie-down feature.

When the pushbuttons on the three-way valves have been held depressed long enough for pressure to equalize on both sides of the cutout valve, both inlet and outlet ports are blocked, thus maintaining operating pressure on the four-way hydraulic valve. Construction of the cutout valve is such that both pushbuttons must be released before the valve resets to permit inlet air to again be applied to the hydraulic valve.

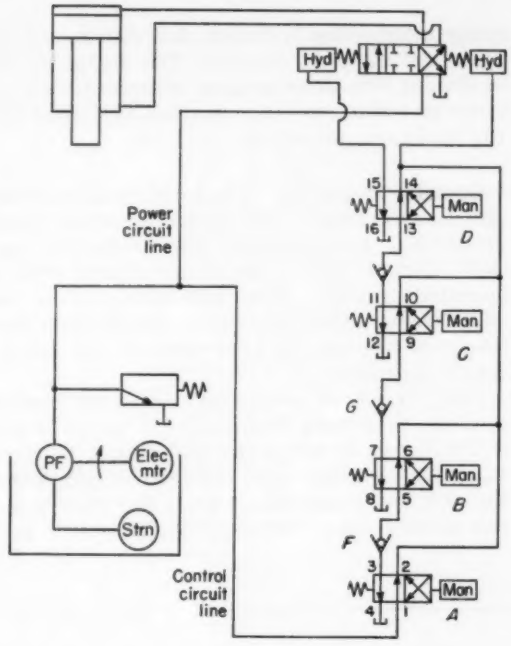

Fig. 2—This two-man safety circuit used on a large press makes movement of the press ram impossible until both operators are ready and have their hands on the operating handles of the four manual valves. With the four valves operated, the hydraulically operated valve energizes the cylinder to perform the press cycle. Since all four valves must be released to retract the cylinder, this circuit also incorporates the nontie-down feature.

Regardless of which valve is tied down, flow from the pump required to energize the four-way, three-position, hydraulically operated valve for the retracting portion of the cycle would be bypassed to the reservoir. For example, if valve *B* were tied down, fluid from the pump would come from the pump to port 1 of valve *A*, out port 2 and then back to tank through ports 6 and 8 of valve *B*. Spool of the hydraulically operated valve would then remain centered blocking all ports and preventing cylinder retraction.

Tying down valves *C* or *D* would produce a similar result. Tying down valve *A* will, of course, direct the fluid from port 1 to port 3 of valve *A*, then through ports 5 and 6 of valve *B* directly back to tank through ports 2 and 4 of valve *A*.

HIGHER machine operating speeds and more intricate machines make the design of safe machines increasingly important and cause insurance companies, unions and management groups to keep a sharp lookout for safety hazards. Usually the mention of safety brings to mind operator protection. Although operator protection is of utmost importance, the investment represented by a machine and the work-piece must also be considered and protected.

This article concerns itself with some of the methods used to make hydraulic circuits safe. Hydraulic circuits may be used to perform various functions in machines and lend themselves well to

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safety interlocking in conjunction with both pneumatic and electrical controls. The discussion will be divided into three sections concerned with (1) operator protection, (2) machine protection and (3) workpiece protection.

Operator Protection: It is a well established fact that many operators will try to circumvent safety devices in order to increase their production, especially if they are working under a piece work or incentive program. They will take chances that will often endanger their limbs. The designer must take this into consideration when laying out hydraulic circuits.

Using a circuit employing two hand controls does not necessarily mean that the circuit is safe. If the circuit is not properly designed, the operator may tie down one of the controls and operate the circuit with one hand, leaving the other to feed and extract the workpiece. This hand will be in

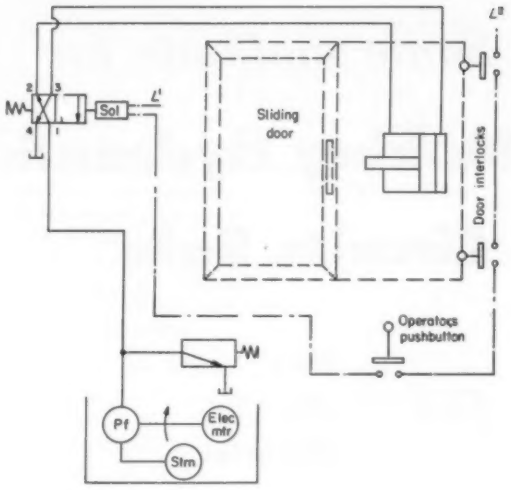


Fig. 4—When access to a hazardous area is by means of a door which should be closed to prevent harm to the operator during the operating cycle, the door should be interlocked with the control circuit. Here, two interlock switches must be contacted and operated by closing the door before the operator can energize the solenoid valve. If an attempt to open the door were made while the ram was in motion, the spring-returned solenoid valve would immediately reverse fluid flow to retract the piston.

Fig. 3—Remote position indication permits an operator to control cylinder movement while not actually within view of the working cylinder. In this circuit, indication is provided by a cylinder which is identical with the working cylinder. As the circuit shows, fluid to operate the working cylinder either comes from or is forced to the indicating cylinder. Since the cylinders are identical, equal movement results.

Initial phasing or adjustment, when necessary, is accomplished by first moving the piston of the working cylinder to the extreme left. Then, if the piston of the indicating cylinder has not also moved to the extreme left, the normally open phasing valve is closed and the normally closed valve opened. This forces the indicating-cylinder piston to move to the extreme left. The normally closed valve is then reclosed and the normally open valve reopened.

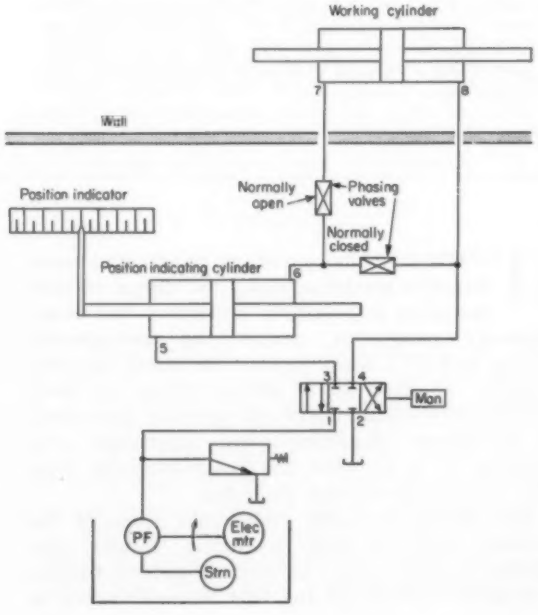
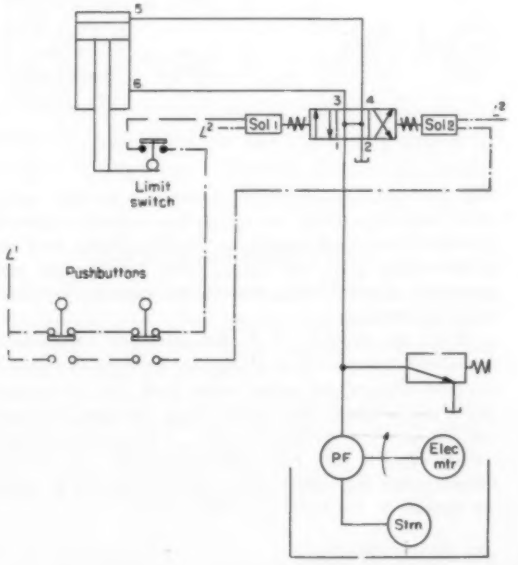


Fig. 5—Solenoid-operated valves permit the operator to be located at a distance from the hydraulic cylinder in this circuit without extremely long runs of pipe. The circuit is used for handling extremely hot billets. Non-tie-down feature is also provided by this circuit since both pushbuttons must be released to complete the electrical circuit to solenoid 1, and shift the valve spool to cause the piston to retract. The piston rod-operated limit switch automatically breaks this circuit when the rod is fully retracted. Valve spool is then centered by springs and the open-center valve returns pump output directly to the tank to prevent excessive heating of the oil during standby.



potential danger of being contacted by the operating mechanism.

A nontie-down circuit, Fig. 1, will force the operator to use both hands if the two operating pushbuttons are properly located. The pushbuttons must be situated so that the operator cannot use a knee or foot to depress one of the controls which would allow one hand to be free. They also must be located so that a bar held in one hand cannot be used to depress both controls and leave one hand free to feed in the work.

Safety controls of this type are needed on many types of hydraulic presses, sizing machines, coining machines, and any other type of machine or process where an operator has a chance to endanger a limb during an operating cycle. The circuit shown, Fig. 1, is used on a sizing machine for thin-wall tubing.

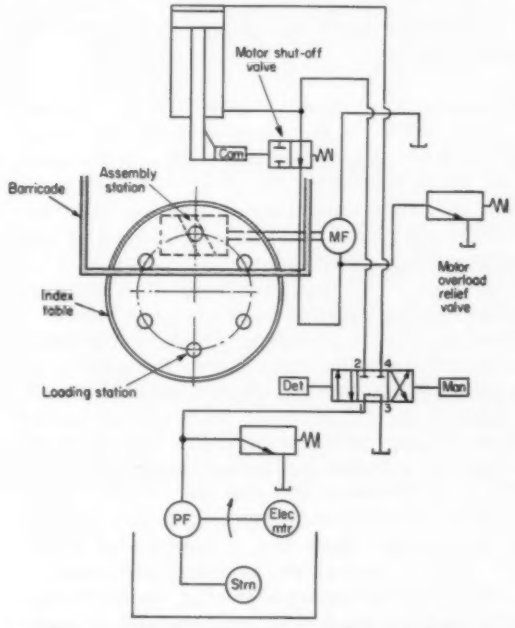


Fig. 6—Overload protection and safety interlocking are provided in this circuit used to operate an index table and an assembly cylinder. When the operator has loaded the machine, the control valve is moved to connect ports 1 and 2 which allows fluid to flow to the rod end of the assembly cylinder as well as to the motor shutoff valve. This causes the assembly cylinder piston to retract. When the piston is fully retracted, a cam on the rod operates the motor shutoff valve to start the motor and index the table.

The cam-operated valve makes it impossible to damage workpiece or machine by indexing the table when the cylinder is not retracted. When the table has indexed to correct position, the operator shifts the control valve to connect ports 1 and 4 which extends the piston to perform the assembly operation. The motor overload relief valve in this circuit is set to limit torque which the motor can exert to some value which will not damage the indexing mechanism. This provision does not limit the pressure which can be exerted by the cylinder.

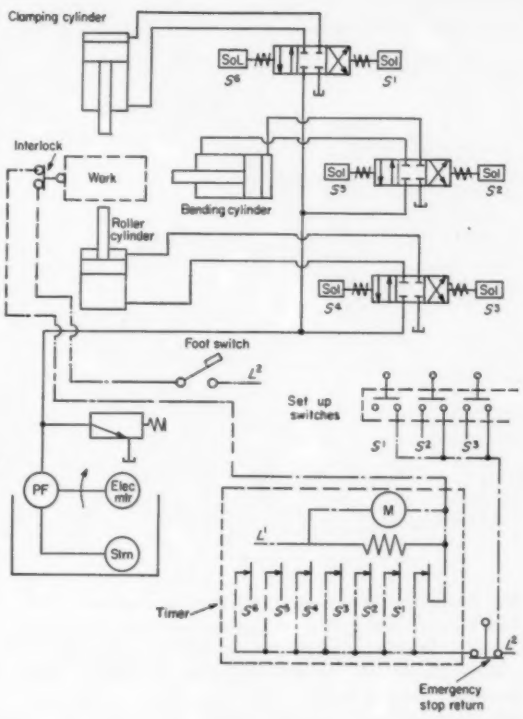


Fig. 7—In this circuit, the normal operating sequence is controlled by timer-operated switches and solenoid valves. An interlock switch and a footswitch in series must both be operated to initiate the timed cycle. Set-up switches permit extension or retraction of the pistons for checking and adjustments. Since release of the footswitch would stop the cycle but not cause contacts closed by the timer to open, an emergency-stop pushbutton is included in the circuit to break the circuit to all valve solenoids and stop any piston which is in motion.

In the normal operating sequence, work is first clamped by the clamp cylinder; the bending cylinder then extends to make a bend, and the roller cylinder retracts to perform its operation. Roller cylinder is then extended and then bending and clamping cylinders are retracted in that order.

Often large machines require two operators. It is then advisable to use controls which must be contacted by both hands of both operators before the machine will cycle. This not only provides safety for the operators who in some cases cannot see each other but also protects the workpiece and the machine. A circuit of this type is shown in Fig. 2.

In some instances an operator must be able to actuate a machine and observe its performance without actually being in the same room or area as the machine. Examples of situations requiring this type of operation include processing of extremely hot materials, explosives and materials which may emit deadly fumes. Such situations can be handled by circuits incorporating remote posi-

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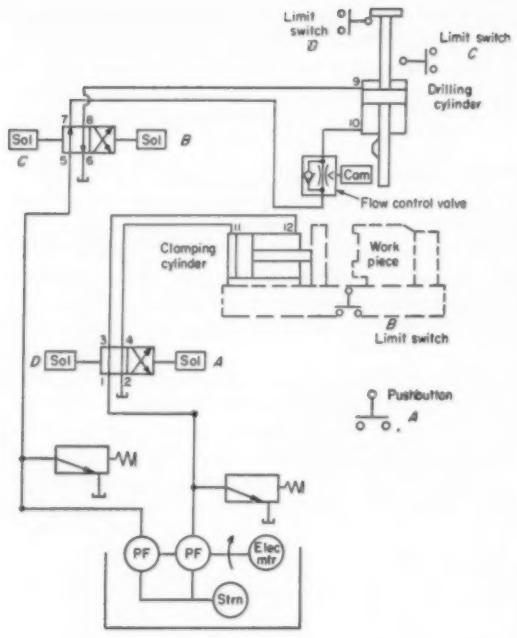


Fig. 8—Independent control of clamping pressure, drill feed pressure and drill feed rate is incorporated in this circuit. Separate pumps and individual relief valves provide the means for controlling clamping and drilling pressures independently. The flow-control valve controls drill feed rate.

After positioning the workpiece, the operator initiates the machine cycle by depressing pushbutton *A* momentarily. This energizes solenoid *A* to shift the clamping control valve spool so as to connect ports 1 and 4 and extend the clamping cylinder. As the clamping piston nears the end of its stroke, it operates limit switch *B* to energize solenoid *B* of the drilling cylinder control valve. Solenoid *B* then shifts the valve spool to connect ports 5 and 8 and start the piston of the drilling cylinder in motion. Initially, the rate of advance of this piston is determined only by piston size and pump capacity and is fairly rapid. As the drill approaches the workpiece, a cam on the piston rod actuates the flow control valve to reduce rod advance speed to a controlled rate for drilling.

At the end of the drilling stroke, limit switch *C* is operated to energize solenoid *C* and retract the drilling cylinder piston. As the end of the retracting stroke is neared, limit switch *D* is tripped to energize solenoid *D* and retract the clamping piston. Limit switch trips are the swing type actuated by motion in one direction only.

tion indication when the operator must be protected by a wall or barricade, Fig. 3. A system of mirrors or simply a window might also be used to allow remote control. When the operator uses a door to gain access to a hazardous area to insert and remove workpieces, the door should be interlocked to prevent injury which might occur if the door were accidentally left open, Fig. 4. Of course, there are many instances where it is sufficient protection to have the operator's station fairly remote from the actual work station, Fig. 5.

Machine Protection: Hydraulics can be used in many ways to provide protection from overloads, positive sequencing, emergency stops, setup-controls, etc. Elimination of machine damage and the ensuing repairs as well as production losses are, of course, highly desirable. An example of a hydraulic circuit which provides both overload protection and safety interlocking is given in Fig. 6.

Other functions which may be desirable for machine protection are low operating pressures during setup, setup controls for each movement, and an emergency stop that will immediately stop all motion, Fig. 7. By setting the relief valve at a pressure just high enough to put the cylinders into motion, the operator can cycle the machine at very low pressure to check the sequence of operation. Setup controls permit checking each phase of operation at full pressure. Emergency stops can be used if some malfunction should occur during th machine cycle to return all cylinders to starting position.

Workpiece Protection: Where multiple operations are performed on a workpiece in one large machine, such as a transfer machine for engine blocks, motor housings, etc., the workpiece must receive as much protection as possible in order to keep scrap losses to a minimum. Some of the possible mishaps which can be neatly prevented by hydraulics are: improper positioning, incorrect feed or pressure, and loosening in the holding fixture.

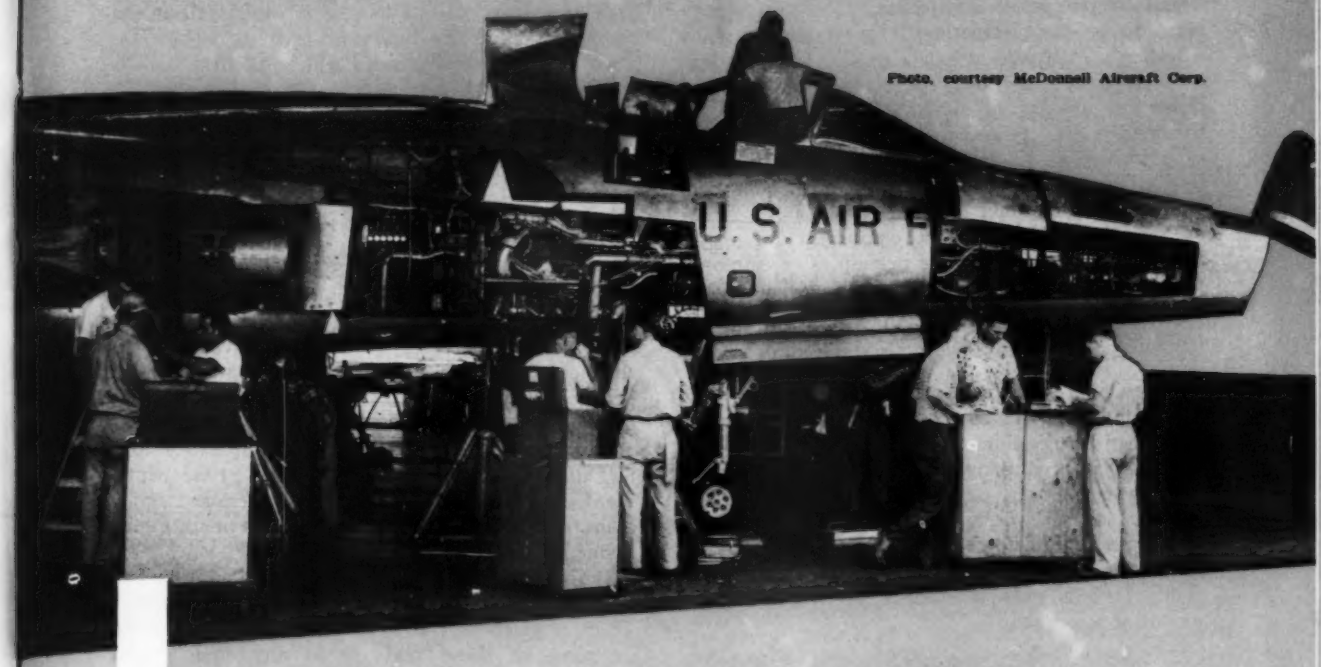
When used as a clamping device, a hydraulic cylinder will exert the same force over a range of ram movement to compensate for irregularities in the workpieces, Fig. 8. Feed rates for operations such as drilling may also be easily controlled for a variety of material hardnesses by a simple adjustment of the relief valve in the circuit.

Accurate and positive positioning is also possible with hydraulics. Both linear position of a hydraulic cylinder ram as well as rotary positioning or indexing can be accuratey controlled. Such circuitry usually employs small limit switches and solenoid-operated valves, Fig. 8.

Storage of hydraulic power in an accumulator also has safety implications. In the event of an electrical power failure and the ensuing stoppage of the pump-drive motor, sufficient energy may be supplied by an accumulator to hold a workpiece in position or perhaps to complete a machine cycle. This ability can be looked upon as an increase measure of safety for machine and operator as well as workpiece.

"No industrial concern can afford to develop all the ideas which might turn into new products. Engineers competent to evaluate the technical difficulties of engineering and production and the worth of the product in a technological society must be a part of the management team that accepts or rejects the idea." — COLONEL O. G. HAYWOOD, *USAFR*.

DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY *(Tenth of a Series)*



Photo, courtesy McDonnell Aircraft Corp.

Maintenance Auxiliaries

Electronic Test Equipment
Bench Mock-Ups
Tools

By John D. Folley Jr. and James W. Altman
Research Scientists, American Institute for Research, Pittsburgh

Basic recommendations for good design of special electronic test equipment and bench mock-ups are discussed in this article. A comparison of four types of test equipment is made. Suggestions are also given for designing electronic equipment to minimize the number of tools required or the need for special tools.

ELECTRONIC test equipment and bench mock-ups of electronic equipment are usually quite necessary for locating malfunctioning parts. However, this equipment can be of maximum value only when properly designed and used. Design of both prime and auxiliary electronic equipment can also greatly affect the tool requirements for maintenance purposes. This article covers the major design considerations for each of these maintenance auxiliaries. The first to be discussed is test equipment.

Electronic Test Equipment

The role of electronic test equipment in maintenance is to collect information from the prime equipment and display it to the maintenance technician. In order to derive the required informa-

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tion, it is sometimes necessary to introduce a test signal to the prime equipment. For test equipment to be most effective, it must clearly show whether a malfunction exists or not in a particular component or group of components. Sometimes the amount of signal distortion caused by the malfunction is required. Operations required of a technician to use test equipment should not be too difficult, complicated, awkward, time consuming, or dangerous.

Basically, design of test equipment for maintainability follows the same principles as employed for prime electronic equipment. Detailed recommendations on human engineering of test equipment are available.*

Types of Test Equipment: Four basic types of test equipment will be considered here. The first is built-in test equipment which is an integral part of the prime equipment. It may be a complex automatic checker or a simple voltmeter with external leads.

The next is go/no-go test equipment; it provides only one of two alternative answers to any question. It tells only whether a given signal is in or out of tolerance.

*P. Spector, A. D. Swain and D. Meister—"Human Factors in the Design of Electronics Test Equipment," *RADC Technical Report* 55-83, April, 1955.

The third type is automatic test equipment. This equipment checks two or more signals in sequence without the intervention of a technician. The sequence usually stops when the first out-of-tolerance signal is detected.

The fourth is collating test equipment which presents the results of two or more checks as a single display. For example, a light may come on only if a number of different signals are in tolerance.

General Considerations: Simplifying the job of the prime-equipment technician by providing built-in, go/no-go, automatic, and collating test equipment will not necessarily reduce the overall maintenance load. However, elaborate test equipment can reduce preparation time or turn-around time of prime equipment, as with missiles and interceptor aircraft. In effect, the maintenance load is shifted back one stage from the prime equipment. Problems in maintaining complex test equipment can offset their advantages in maintaining prime equipment.

Built-in, go/no-go, automatic, and collation features are all virtually independent of each other. Thus, a given test equipment may have all, none, or some of these features in any combination. Also, a given test equipment may be partially built-in, partially go/no-go, etc.

Table 1—Comparison of Four Types of Test Equipment

Test Equipment	Advantages	Drawbacks
Built-In	1. Less likely than portable test equipment to be lost or damaged. 2. Available when needed. 3. No special storage facilities. 4. Transportation to the prime equipment for use in maintenance is not required.	1. Likely to add to the weight and space requirements of the prime equipment which is a strong disadvantage in airborne equipment. 2. More built-in test equipments may be required because a separate item is usually required for each prime equipment. 3. Transportation of built-in test equipments to a point for convenient calibration may be more difficult than transportation of portable test equipment. 4. Permanent installation of the test equipment may increase the complexity of wiring for the system and may even increase the amount of required maintenance for the prime equipment.
Go/No-Go	1. Presents information that is clear and unambiguous. 2. Usually easy to read. 3. Can simplify difficult tasks such as balancing circuits or checking complex waveshapes.	1. Unique circuitry usually required for each signal value to be tested. Sometimes, however, ordinary displays can be converted to go/no-go by appropriate use of reference scales such as a colored section on a meter dial. 2. Increase in the number and complexity of circuits usually required adds to initial cost and development time; it is also likely to increase the rate of test equipment breakdown. 3. Except in long, fast check sequences, go/no-go equipment is of relatively little help to the technician in checking common voltages or simple waveshapes. 4. Likely to require modification when prime equipment is modified. A special model may be required for each model of prime equipment.
Automatic	1. Can make a rapid sequence of checks with little or no chance of omitting any steps.	1. Cost, size, weight, and maintenance requirements are relatively high. 2. This type of equipment is relatively specialized, with little versatility. 3. Must almost necessarily have self-checking features to detect test equipment malfunctioning. This adds to cost and to problems of maintaining the test equipment. 4. More likely to require modification when prime equipment is modified. A special model may be required for each model of prime equipment.
Collating	1. Reduces the number of displays the technician must read, thereby reducing check time and probably reducing errors. 2. Collating test equipment should indicate not only that all signals are or are not in tolerance; it should also provide an indication of which signal, if any, is out of tolerance. If only the collated display is presented, the equipment will not be an aid to trouble shooting.	1. Similar to those for go/no-go and automatic test equipments.

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No general prescription can be made specifying how much of each characteristic should be incorporated in a given item of test equipment. The relative importance of the advantages and disadvantages of each characteristic must be judged in view of the demands that will be placed upon the equipment and maintenance personnel in the field. A comparison of the four types of test equipment discussed here is made in Table 1.

Difficulty of Use: Assess the difficulty of operating a proposed test set early in its development, certainly not later than building of a nonfunctional mockup, by having typical personnel "walk through" the operating procedures.

The operation of the test equipment is probably too difficult (1) if personnel who are reasonably proficient at operating other test equipment have to acquire extensive new skills in order to operate the tester being developed, or (2) if personnel make errors in operating the tester even when following written instructions.

To simplify use of test equipment, minimize the number of controls and displays. Also, reduce the number and complexity of steps required for operation. This can be done by "ganging" certain setup controls and/or making certain sequences of operations automatic. Then, too, be sure to write clear instructions.

Controls and Displays: Exact indications should be presented on test equipment display, rather than requiring multiplication or other transformation of display values. If transformation of display values is required, a conversion table should be provided on the test equipment. If it is not feasible to provide a conversion table, each transformation factor should be indicated beside each switch position or display scale requiring the use of that factor. Use decimal transformation factors to simplify arithmetic requirements.

Only the scale being used at a given time should be in the technician's view. This eliminates the possibility of reading the wrong scale. Whenever more than one scale must be in the technician's view, they should be clearly differentiated from each other by labeling and color coding to their respective control positions.

Provide "reverse interlocks" that turn off the test equipment when the test-equipment lid is closed. Incorporate written warnings on test equipment to insure that it will be turned off when testing is completed.

Basic design recommendations for controls, displays, and control-display relationships were given in Parts 7 and 8 of this series of articles in (September 20, 1956 and October 4, 1956).

Provide selector switches on test equipment instead of requiring plug-in connection, Fig. 1. Selector switches require less time to select the proper function and eliminate the possibility of leads falling out of the receptacle.

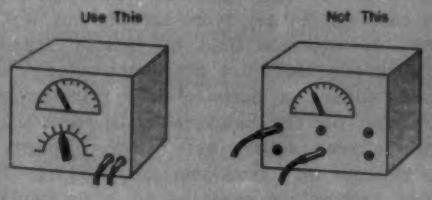


Fig. 1—Provide selector switches on test equipment instead of plug-in connections.

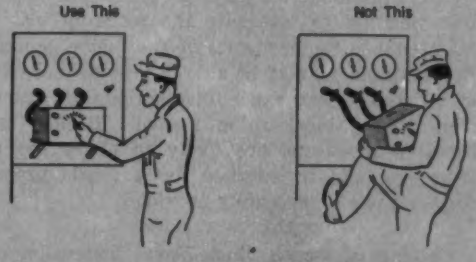


Fig. 2—A pull-out shelf or some method of supporting test equipment should be incorporated in prime electronic equipment, particularly heavy units.

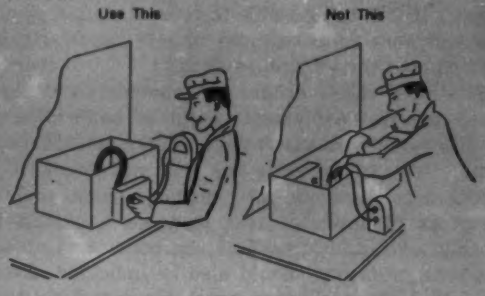


Fig. 3—Provide extension cables in bench mock-ups for functional checking.

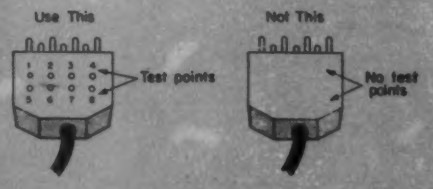


Fig. 4—Cables for mock-ups should have test points available to check current characteristics in each wire.

XUM

Storage and Handling Provisions: Portable test equipment should be rectangular in shape for convenient storage.

Handles on the outside case of portable test equipment should be recessed or hinged so they do not take up excessive storage space.

In the design of the prime electronic equipment, provision should be made for setting test equipment down while it is being used, Fig. 2. Even light equipment may be cumbersome to hold while checks are being made.

Test Leads and Adaptors: Provide adequate storage space in the lid or cover of test equipment for storage of removable items such as leads and adaptors. Indicate the proper locations for the various items that go into the storage space. Provide fasteners or holders in storage compartments for accessories to prevent damage to the test equipment or accessories.

Test leads should require no more than a fraction of a turn for attachment to prime equipment receptacles, unless attachment is permanent.

Whenever adapters must be used, they should be a part of the test equipment removable items. This prevents their loss, reduces probability of damage, and saves time in setting up the test equipment.

Design Suggestions: Windows for test-equipment dials should be as resistant to breaking or scratching as possible. A signal that indicates when test equipment is warmed up should be provided. If it is not feasible to present such a signal, the warm-up time required should be clearly indicated near the warm-up switch.

A simple check should be provided to indicate when the test equipment is out of calibration or is otherwise malfunctioning. There should be a simple way to calibrate the test equipment.

The outer case and all removable parts, such as adaptors or leads of test equipment, should be clearly labeled. Purpose of the tester and special cautions in its use should also be indicated. Every item that the technician must recognize, read, or manipulate should be labeled. These would include dials, knobs, switches, lights, etc.

Provide circuit-protection devices, such as circuit breakers and fuses, that will safeguard equipment against damage if the wrong switch or jack position is used.

Instructions for using a test equipment should be stored in its lid or in a special compartment in the tester to ensure that the instructions are always available. A checklist for operating the test equipment might be printed on a metal plate and attached to the equipment.

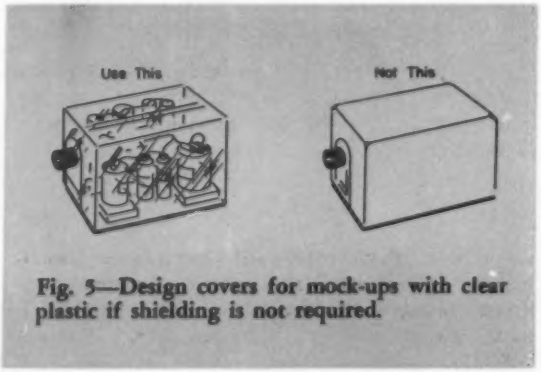


Fig. 5—Design covers for mock-ups with clear plastic if shielding is not required.

Bench Mock-Ups

The term "bench mock-up" is used here to mean a prime piece of electronic equipment set up in a maintenance shop in the field or at the factory to check and/or trouble shoot units brought in by the customer. A mock-up may consist of an entire electronic - equipment system or only a portion of a system. Either type may be provided with signal generators and dummy loads to simulate inputs from and outputs to the physical environment, for example, radar waves.

Mock-ups are used in trouble shooting by replacing a unit of the mock-up with a unit suspected of containing a malfunction. The remaining portions of the mock-up are then used to feed signals into and receive signals from the suspected component. If a malfunction symptom appears when the suspected unit is installed, but not when the regular mock-up unit is installed, it is concluded that the suspected unit is malfunctioning.

General Design Considerations: Bench mock-ups should be factory built. Mock-ups should be designed as if they were an item of test equipment, to expedite field or factory maintenance procedures. Mock-ups are constructed essentially from production units of the prime equipment. However, for the mock-up to be most useful for maintenance, signal generators, dummy loads, extra junction boxes, special cabling, terminal strips, test points, cases, controls, or displays may be required. If technicians must construct their own mock-ups in the field from spare prime-equipment units and spare bits and pieces locally available, they may have difficulty in providing these desirable features.

The equipment designer probably will be in the best position to integrate the mock-up into total maintenance requirements of the prime equipment. For example, he may be able to provide more specific written maintenance instructions if exact design of the mock-up is known. Locally manufactured mock-ups are likely to differ too much from one site to another for a single procedure for their use to be readily provided.

Cabling of Bench Mock-Ups: Extension cables should be provided for subunits so they can be removed from the larger units for functional checking, Fig. 3.

End connectors on all mock-up cables should require only a strong push or a pull to connect or disconnect them. Mock-up cables need not

withstand strong vibration or shock. Because of the way in which mock-ups are used; however, they do need to be connected and disconnected frequently.

Provide extra heavy coverings on mock-up cables (for example, vinyl tubing) to protect them from wear caused by frequent connection and disconnection.

Mock-up cables, including extension cables for subunits, should provide a test point to check the signal flow through each wire. Usually this can be done effectively at the connector pins as shown in Fig. 4. In some cases it may be more convenient to provide certain of the test points on junction boxes or terminal strips. Each test point should be clearly labeled. Job instructions for the mock-up man should give correct signal values and tolerances for each test point.

When an assembled mock-up is not provided, supply a set of cables for interconnecting the equipment units to aid field personnel in setting up the mock-up.

Covers and Cases: Mock-up units containing parts whose operation may be checked visually should have transparent plastic covers, Fig. 5*a*, rather than metal covers, Fig. 5*b*, if electrical shielding is not necessary.

Layout: Mock-up units should be stacked in a configuration that makes every unit accessible without removing any other unit. Layout of mock-ups should provide adequate space for use of test equipment, including space for setting test equipment down while it is being used.

Tools

Tool requirements are directly derivable from consideration of necessary maintenance operations and the design characteristics of the electronic equipment involved. Tools must be specified and/or designed as an integral part of designing electronic equipment for maintainability.

Neglecting consideration of tool requirements until equipment design and procedures are final is likely to result in a need for many special tools or an unnecessarily wide variety of standard tools.

Each equipment system should be accompanied by a comprehensive list of tools needed for all maintenance tasks. All tools on this list should be tried out during developmental testing of the system to uncover duplications and omissions, and to discover equipment design features that require more tools than necessary. One small unit seen in the field has slotted screws, Allen-head screws, and hex-head screws on the front panel alone. This practice should be carefully avoided. Requirements for special tools should be kept to a minimum. Also, the variety of tools required should be minimized.

BIBLIOGRAPHY

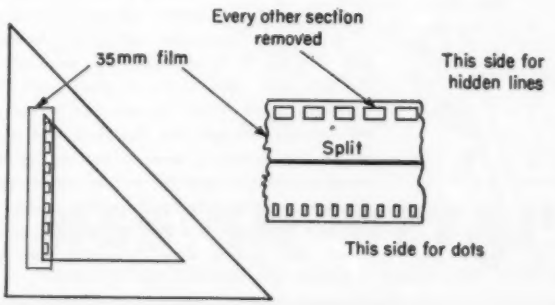
This article is the tenth in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

Designing Electronic Equipment for Maintainability ..... June 14, 1956
Units, Assemblies and Subassemblies ..... June 28, 1956
Covers and Cases ..... July 12, 1956
Wiring, Cables and Connectors ..... July 26, 1956
Maintenance Accesses ..... Aug. 9, 1956
Test Points ..... Sept. 6, 1956
Controls ..... Sept. 20, 1956
Displays ..... Oct. 4, 1956
Equipment Installation ..... Oct. 18, 1956

Tips and Techniques

Dotting Guide

Uniform dotted or dashed lines may be easily drawn by using a strip of 35-mm photographic film as a guide. This also allows these lines to be drawn without lifting the pencil from the paper. The film is split as shown and then fastened to a triangle or straightedge. Removal of alternate sections, between perforations gives dashes rather than dots as shown.—ROGER O. WALES, *Bettendorf, Iowa.*



Strength of Small Shafts

The following formula for shaft diameter has proved to be quite useful and of sufficient accuracy when working with small shafts where power transmitted is usually measured in watts.

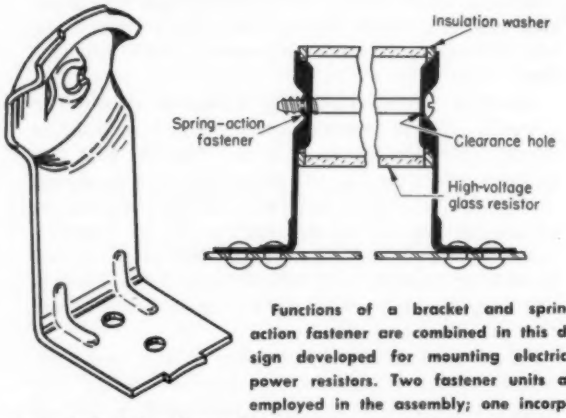
$$d = 75 \sqrt[3]{\frac{P}{NS}}$$

where N = shaft speed, 1000 *rpm;* S = design stress of the material, 1000 psi; P = power transmitted, watts; and d = shaft diameter, 0.001-in.—ARNE BENSON, *Sanders Associates Inc., Nashua, N. H.*

XUM

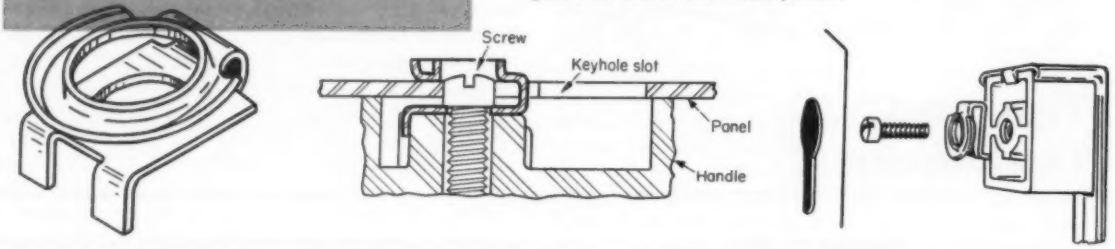
Multiple-Function Fasteners

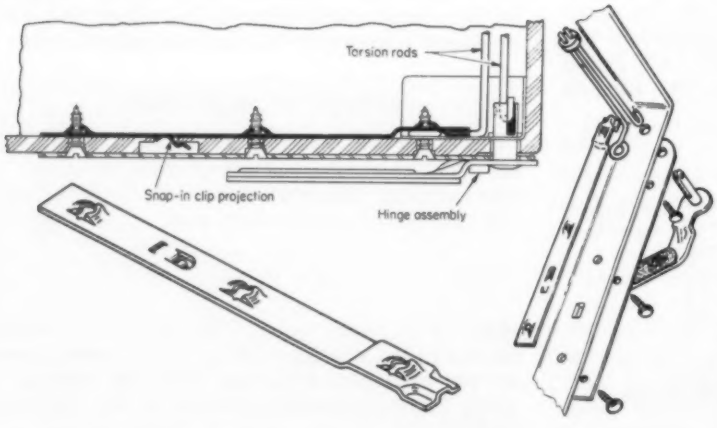
Designed to simplify and accelerate assembly operations, a number of fasteners have been developed to perform one or several functions in addition to the primary job of fastening. Serving as a spacer, bracket, spring, friction brake or in other auxiliary functions, these "multiple - function" fasteners frequently offer cost advantages in reducing the number of parts required for assembly. In addition, production operations such as welding, clinching, staking and riveting can often be eliminated. Typical types and applications of multiple-function fasteners manufactured by Tinnerman Products Inc. are shown in the accompanying illustrations. All incorporate some form of spring-action locking or retaining device. Although the types shown were developed to solve specific problems, application characteristics permit adaptation to other similar design situations.



Functions of a bracket and spring-action fastener are combined in this design developed for mounting electrical power resistors. Two fastener units are employed in the assembly; one incorporates a helical thread-engaging impression, the other a clearance or mounting hole. A concave locating emboss in the vertical legs of each fastener member accommodates the ends of the resistor which is pressed between the brackets and held firmly under spring tension. A through-bolt inserted through the legs and resistor completes the assembly.

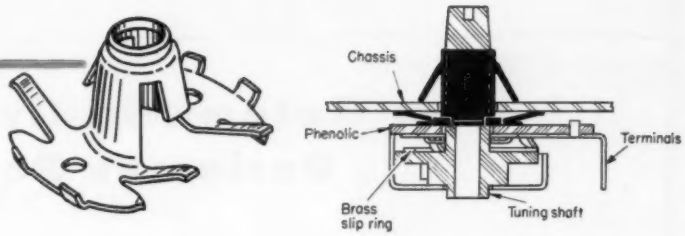
Handle attachment for appliance door assembly permits easy disassembly for maintenance or cleaning. In addition, resilience of fastener prevents marring of finished door surface and can accommodate variations in panel thickness. Functions of a sleeve, cup retainer, and coiled spring are combined in the one-piece design. In assembly, the fastener is secured to the handle with a screw. Self-locating characteristic of fastener prevents turning while screw is tightened. As the handle is assembled to door, U-shaped section of fastener straddles door panel and is held firmly by spring action. Screw head doubles as a dowel and guides the handle into locked position.



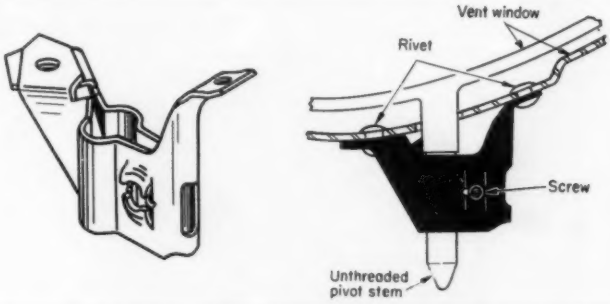


Strip fastener for appliance door assembly has three spring-action thread-engaging impressions and serves as both a hinge and a torsion rod spring anchor. Mounted to a plastic door panel, the fastener provides a vibration-resistant attachment with wide bearing surface to reinforce and strengthen the plastic material. A special clip projection makes the fastener self-retaining; it is snapped into position on the door and holds firmly in place while the assembly is completed. An embossed section of the fastener engages the eyeletted end of a torsion rod which is secured by one of the hinge mounting screws. The torsion rod engages a hinge pin assembly on the opposite side of the door to provide a gentle but positive spring action that returns door to sealed position.

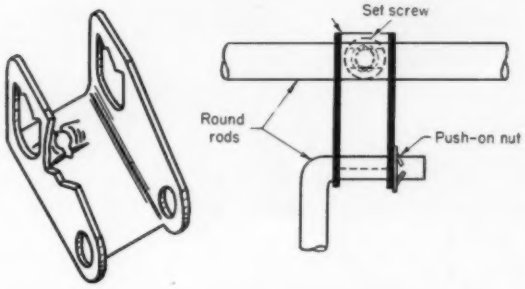
Clip-type fastener is designed for rapid mounting of electronic control unit to chassis. Fastener snaps into chassis by hand where it is self-retained. Spring fingers lock control unit in position, spacing it required distance from the surface of the chassis.

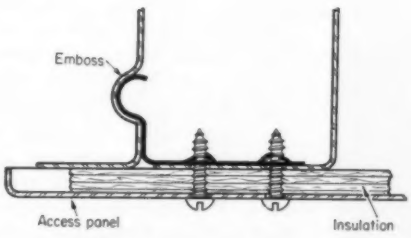


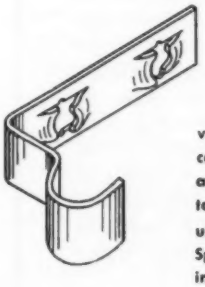
Speed Nut design provides clamping action on pivot stem of window vent for automotive applications. Eliminating over 14 parts used in a previous design, the fastener secures pivot, develops proper pivotal action and assures accurate alignment of assembly.



Rod attachment design is self-retaining and assures proper adjustment and spacing of operating parts. Set screw is mounted in spring-action thread-engaging impression on one end of bracket to hold one of the rods firmly in place. Other rod, held in position by push-on nut, is free to rotate for adjustment.

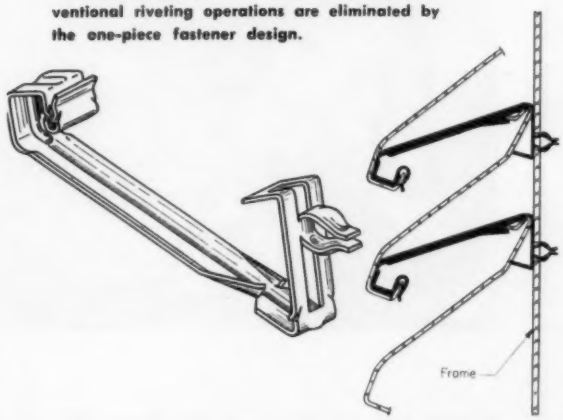






Strip-type fastener is used to retain access panels in assemblies requiring insulated construction to prevent heat losses. Fastener retains access cover, insulation and baffle plate as well as providing a spring-catch to retain unit to structure. In assembly, unit is simply pressed into position. Spring steel arms on the clip snap into embossed recesses and hold the unit in place under spring tension.

Self-retaining clip-type fastener secures louvers, or similar parts, to metal frame member. Dart on clip snaps into hole in frame. Louver is then positioned and pressed into place. Barbs in U-shaped section of clip secure one louver, while other end of clip engages with another, locking it under spring tension. Conventional riveting operations are eliminated by the one-piece fastener design.

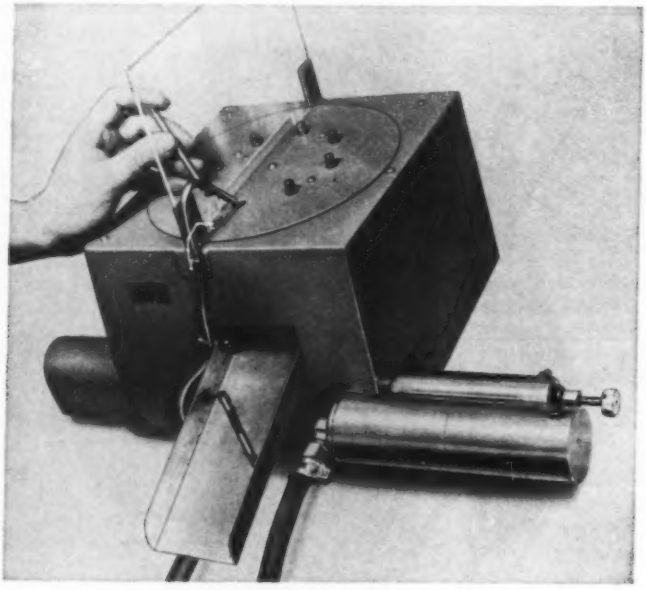


DESIGN DETAILS

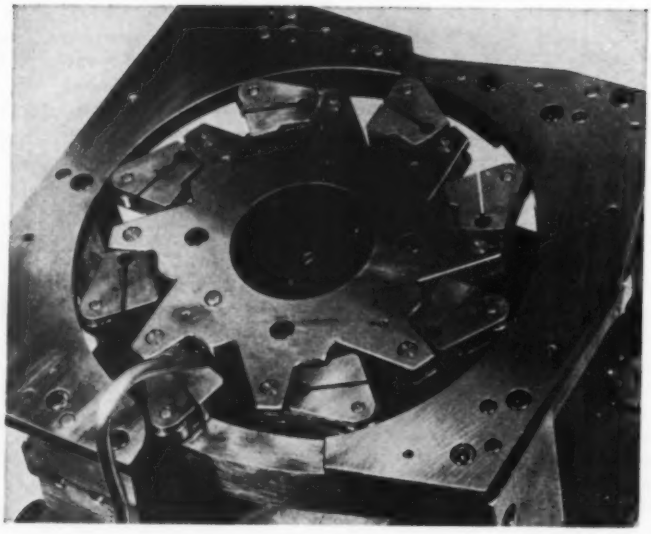
Practical solutions for design problems with standard components

XUM

Cam Automatically Clamps, Unclamps Parts



TIGHT clamping of cylindrical parts is automatically provided in a recently announced rotary indexing table by cam and follower action. Developed by Amco Machine Products Inc., the device is an adaptation of a Mead Specialties Co. rotary feed table. The machine is used to hold a cylindrical piece of nominal ¼-in. diam while a square head is milled by two sets of straddle cutters. Parts must be tightly held against rotation during the operations so the faces of the head will be square within ±0.002-in.



Cam ring and split follower blocks provide controlled clamping force. Teeth on contact faces of the follower blocks help to prevent rotation of the parts during milling operations. A segment of the circular cam is cut out so no gripping force is exerted at the loading and unloading stations. Parts are loaded simply by dropping them into holes in the top plate of the machine. When operations are completed and the table indexes to the unloading position, clamping force is released. An air jet is then sufficient to cause the finished piece to fall into a discharge chute. Chips are also blown away by the jet.

Contemporary Design

Analyzing effect of bending loads on

Bolted Flange Joints

By B. B. Clements*
Lincoln, England

BOLTED flange joints must often be designed to carry a bending moment as well as tension and compression loads. This condition is common to pressure and other types of connections where the joint becomes part of or serves as a main structural member. If proper allowance for the effect of bending action is not provided in the joint construction, leakage may occur as a result of separation at the joint surfaces.

This article presents a quick and simple method for analysis of circular and semicircular bolted joints subject to both pressure and bending loads. Equations are provided for estimating the maximum moment at which joint separation will occur.

Basic assumptions for this analysis are:

1. Flanges are sufficiently rigid for their deflections to be neglected.
2. Gasket is resilient and has the same properties in tension as compression; that is, it behaves as a spring.
3. Bolts are evenly spaced around the flange bolt circle.

Equations for calculation of bolt and gasket loads in circular and semicircular joints are summarized in Table 1. Their development and application are treated in the following discussion.

Neutral Axis: Consider first a single load-carrying element of a flange having a width of one bolt "pitch" with the bolt located in the middle of the element. Then, if the gasket is replaced by an equivalent spring, it can be shown that applied load W on the element, when it is moved through distance δ, is given by the general expression:

$$W = \frac{\delta}{e}\left(1 + \frac{e}{c}\right) \qquad (1)$$

Thus, from Equation 1, $W = \delta K$, where K is constant for a particular bolt-gasket combination (see Nomenclature).

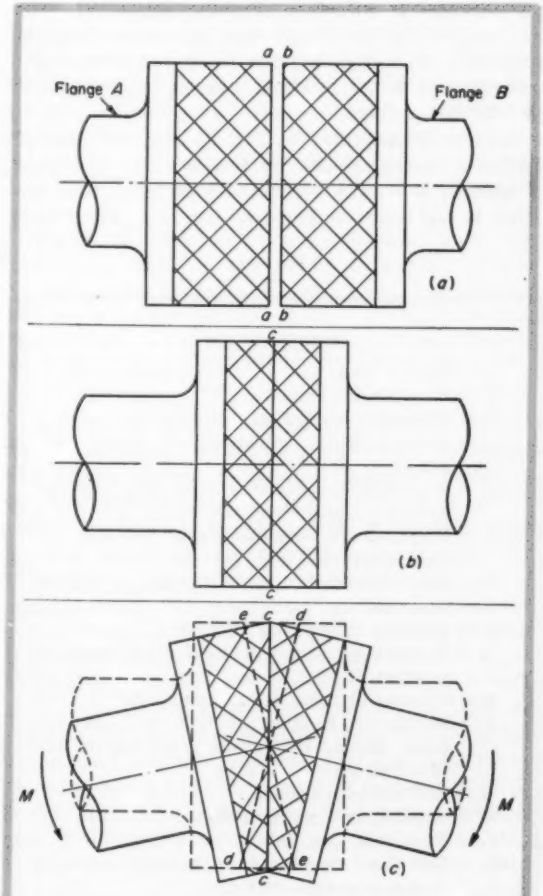


Fig. 1—Effect of tightening and bending loads on position of contact faces in bolted and gasketed circular joint. Gasketed flanges are shown in *a*, in free position; *b*, after initial tightening; and *c*, under bending load.

*Formerly Design Engineer, Turbine Dept., Ruston and Hornsby Ltd., Lincoln, England.

XUM

When the flange is "closed up" a distance δ, the resisting force of the flange element can be replaced by an equivalent force, W, considered to be acting on the bolt. Thus, any bending moment on the joint is resisted by a moment developed by a series of bolt loads along the flange. These bolt loads are proportional to their distance from the neutral axis since each of the flange elements has the same properties under compression or tension. Hence, if the bolts are symmetrically located on the flange, the neutral axis must pass through the centroid of the bolt system.

Full Circular Joints: There are three distinct stages in the behavior of a bolted flange joint under increasing bending moment. At first, movement of the flange will stay within the limits of the compression due to initial tightening of the bolts. Then, when the bending moment reaches a certain value, compression forces will be overcome at one edge and separation will occur, causing leakage at interface. Finally, separation will continue along the flange until the other edge is reached. At this point, the flanges will be fully separated with the bending moment being resisted by the bolts alone.

BEFORE SEPARATION: In Fig. 1*a*, the free face of flange *A* is represented by line *a-a* and of flange *B* by line *b-b*. The resultant interface after the joint is tightened is given by line *c-c*, Fig. 1*b*.

Nomenclature

- C = Gasket load, lb
- C_f = Final gasket load, lb
- C_r = Allowable residual gasket load, lb
- c = Gasket rate (deflection-load ratio), in. per lb
- d = Perpendicular distance from any bolt to axis of rotation (Fig. 2*b*), in.
- d_{max} = Perpendicular distance from top bolt to axis of rotation (Fig. 2*b*), in.
- e = Bolt rate (deflection-load ratio), in. per lb
- K = Constant
- M = Bending moment on joint, lb-in.
- m = Moment of any bolt load about axis of rotation of joint, lb-in.
- N = Number of bolts in full bolt circle
- n = Numbered position of bolt in clockwise order around bolt circle from top or datum bolt where $n = 0$
- R = Bolt circle radius, in.
- W = Applied load on any bolt, lb.
- W_f = Final bolt load, lb
- W_0 = Bolt load developed by bending moment in top or datum bolt, lb
- W_t = Initial tightening load on bolt, lb
- δ = Movement of flange, in.
- θ = Angle between top bolt and any other bolt, measured in a clockwise direction, degrees
- ϕ = Angle between vertical centerline of joint and top bolt of flange (Fig. 2*b*), degrees

When a bending moment is applied to the joint, the resultant interface will remain at line *c-c*, but the flanges will rotate an amount β. Since the flanges are assumed rigid, the net effect is to move interface *c-c* of flange *A* to position *d-d*, of flange *B* to *e-e*, Fig. 1*c*.

Deflection of any point on a face is thus proportional to its distance from the center (axis of rotation). In many ways, the bending action at the joint closely parallels that of a beam member. Since, as previously pointed out, applied load W is proportional to deflection (equivalent relationships in tension and compression), the resisting moment can be represented schematically as shown in Fig. 2. Here two rigid flange members are rotated through an angle β about axis *X-X* to elongate any connecting bolts in proportion to their distance from the axis. The top bolt (farthest from axis *X-X*) is assumed to be at an angle ϕ to the vertical centerline of the joint. If W_0 is the load in the top bolt, then, from Fig. 2*b*, load in any other bolt is given by

$$W = W_0 \frac{d}{d_{max}} \tag{2}$$

and its moment about axis *X-X* is

$$m = \frac{W_0 d^2}{d_{max}} = \frac{W_0 R}{\cos \phi} \cos^2 (\theta + \phi) \tag{3}$$

where θ is defined by

$$\theta = \frac{2\pi n}{N} \tag{4}$$

when $n = 0$ at the top bolt.

From Equation 3, then

$$M = \frac{W_0 R}{\cos \phi} \sum_{n=0}^{n=N-1} \cos^2 (\theta + \phi) \tag{5}$$

Summing the series and solving for W_0 gives

$$W_0 = \frac{2M \cos \phi}{RN} \tag{6}$$

except when $N = 2$.

Thus, the maximum bolt load is

$$W_{f,\,max} = W_t + \frac{2M \cos \phi}{\left(1 + \frac{e}{c}\right) RN} \tag{7}$$

Similarly, the minimum gasket load is

$$C_{f,\,min} = W_t - \frac{2M \cos \phi}{\left(1 + \frac{c}{e}\right) RN} \tag{8}$$

Minimum and maximum values for the angle ϕ are 0 and π/N. Thus, it is evident that the best configuration is to have the joint so disposed to the direction of the applied bending moment that the vertical centerline bisects the angle between two bolts. Change in bolt load for a given applied bending moment will then be a minimum.

INITIAL SEPARATION: For separation, flange extension at maximum load position must equal initial

compression of the gasket. Thus, the gasket force is reduced to zero and, from Equation 8,

$$M = \frac{W_t RN \left(1 + \frac{c}{e}\right)}{2 \cos \phi} \qquad (9)$$

From a practical design standpoint, however, joint failure will occur when the gasket load reduces to some value C_r established by experience and the pressure loading. Therefore,

$$M_{max} = \frac{(W_t - C_r)\, RN \left(1 + \frac{c}{e}\right)}{2 \cos \phi} \qquad (10)$$

FULL SEPARATION: As the condition of full separation is approached, the flanges rotate about their bottom edge which is considered here as coinciding with the bolt circle. Using a similar approach as in the previous analysis gives the maximum bolt load at full separation to be

$$W_{f,\,max} = \frac{2}{3} \frac{M\,(1 + \cos \phi)}{RN} \qquad (11)$$

If this solution is compared with the previous one, Equation 7, it will be seen that an optimistic answer can be obtained if bolt loads are calculated ignoring precompression of the flanges and, hence, assuming rotation about the bottom edges. The error for a metal-to-metal joint with cos $\phi = 1$ is 3/2.

Semicircular Joints: The previous method is also applicable to the case where a full circular joint is split into two semicircular joints; that is, a built-up casing which splits along its longitudinal axis. Here, however, number of bolts N is considered to apply to the full bolt circle, with the stipulation that N is an even number so that the joint can be split symmetrically. Also, for convenience of analysis, it will be assumed that the axis of rotation is parallel to the "splitting" diameter. Thus, it passes through the centroid of the bolt semicircle.

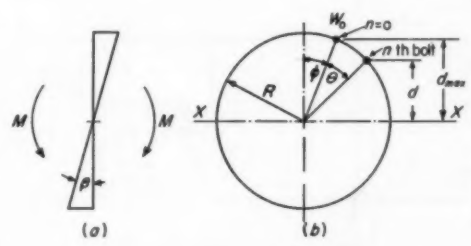


Fig. 2—Relationship of elements in circular bolted flange joint under bending load showing, *a*, schematic representation of resisting moment and, *b*, basic joint nomenclature.

The problem is now reduced into four cases; either an odd or even number of bolts in the half joint with the applied bending moment acting in either direction. It is to be noted that when $N = 6$, the three bolts in the half flange all lie on one side of the axis of rotation. Thus, the equations given in Table 1 are not applicable for this specific case.

Limits of Method: In this analysis, the flange has been split up into segments taken about each bolt with each segment assumed to be extended or compressed a distance depending upon its position. The equations for gasket pressure thus give a mean value over each segment. This can affect the accuracy of predictions of minimum gasket pressure. Depending upon the geometry of the joint, the gasket may "blow" before the predicted separation condition. This possibility can be accommodated by a normal factor of safety.

Another source of error in the method is introduced when the bolts are so distributed that one or two lie on the axis of rotation. Theoretically, these bolts can have no moment, but the gasket pressure variation over these segments will produce one. Thus, the resisting moment will be greater than calculated and the changes in bolt and gasket loads will be less than the estimated values.

These two sources of error depend upon the number of bolts in the joint. If a joint with a large number of bolts is being used, the method can be expected to give fairly accurate results. But if only a few bolts are used, a considerable error could be involved.

Application of Method: A typical example* of the use of the equations is provided by the bolted end flange design of an axial compressor casing for an industrial gas turbine. This casing, which splits horizontally, is also a main structural member and carries a large bending moment that may be multiplied several times by shock loading. Problem is to find (1) maximum bending moment the bolted flange joint can withstand without separation when the casing is complete and (2) bolt loads when the compressor is opened up. Joint details are: $N = 24$, $R = 9\frac{1}{2}$ in., and $W_t = 8000$ lb. Bolts are ½-in. diameter, UNF. Joint is bare metal and carries internal pressure of 46 psi gage. When the compressor is split, a bending moment of $M = 33{,}000$ lb-in. acts on the joint from bottom to top; that is, a hogging moment.

MAXIMUM MOMENT: In a bare metal joint, load on the bolts will not be increased until the initial tightening load is exceeded. The value of c in this case approaches zero. Thus, at separation,

$$W_t = W_0 + C_r$$

where C_r represents the pressure load on a bolt, it being assumed that no residual pressure allow-

*Example, courtesy Ruston and Hornsby Ltd., Lincoln, England.

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ance is required for this transient shock loading case.

Pressure load on each bolt is

$$C_r = \frac{\pi(19)^2(46)}{4\,(24)} = 543 \text{ lb}$$

From Table 1, the condition of maximum bending moment becomes,

$$W_t = \frac{2\,M\cos\phi}{RN} + C_r$$

Substituting appropriate values and solving for M gives $M = 858{,}000$ lb-in. This moment represents the maximum permissible bending load on the joint before any serious leakage due to separation occurs or the bolt stress is effectively increased above the initial tightening value.

BOLT LOADING WITH SPLIT CASING: With the top of the compressor casing removed, the hogging moment on the joint must be carried by the bolts in the bottom half of the flange. From Table 1, for a half flange with moment acting from bottom to top and $N/2 = 12$ (even),

$$W_0 = \frac{33{,}000}{9.5}\,\frac{(0.9914 - 0.4244)}{\left[0.34\,(24) - \dfrac{0.8488}{0.1305}\right]}$$

$$= 1{,}190 \text{ lb}$$

This result is substantially less than initial tightening load and, thus, will not alter bolt stress.

Table I — Equations for Bolted Flange Joints

General Equations

Final bolt load: $W_f = W_t + \dfrac{W_0}{1 + \frac{e}{c}}$

Final gasket load: $C_f = W_t - \dfrac{W_0}{1 + \frac{c}{e}}$

For maximum resisting moment: $W_t = \dfrac{W_0}{1 + \frac{c}{e}} + C_r$

Specific Load Equations

Case	W_0	W_t (full separation)
Full Flange Optimum design, $\phi = \frac{\pi}{N}$	$\dfrac{2\,M\cos\phi}{RN}$	$\dfrac{2}{3}\,\dfrac{M(1+\cos\phi)}{RN}$
Half Flange Top to bottom moment [Not applicable when $N=6$]	$\dfrac{M}{R}\,\dfrac{\left(0.4244 - \sin\frac{\pi}{N}\right)}{\left(0.34N - \dfrac{0.8488}{\sin\frac{\pi}{N}}\right)}$	$\dfrac{M}{2R}\,\dfrac{\left[\sin\frac{\pi}{N}\left(1 - \sin\frac{\pi}{N}\right)\right]}{\left(\frac{3N}{8}\sin\frac{\pi}{N} - 1\right)}$
Bottom to top moment For $N/2$ = odd number: [Not applicable when $N=6$]	$\dfrac{M}{R}\,\dfrac{0.5756}{\left(0.34N - \dfrac{0.8488}{\sin\frac{\pi}{N}}\right)}$	$\dfrac{4\,M}{RN}$
For $N/2$ = even number:	$\dfrac{M}{R}\,\dfrac{\left(\cos\frac{\pi}{N} - 0.4244\right)}{\left(0.34N - \dfrac{0.8488}{\sin\frac{\pi}{N}}\right)}$	$\dfrac{4M\cos\frac{\pi}{N}}{RN}$

Equations are not applicable for $N = 1$ or 2.

DESIGN ABSTRACTS

Electronic Drives

- **Design**
- **Control**
- **Applications**
- **Advantages**

By A. J. Humphrey
Engineering Specialist
Reliance Electric and Engineering Co.
Cleveland

BETWEEN 80 and 90 per cent of the electric drives built today consist of a motor-driven dc generator providing a variable armature voltage for a dc motor. Until 10 years ago an additional dc generator was used to supply excitation for the motor field. This rotating exciter has been largely replaced either with a hot-cathode rectifier or with a dry-plate rectifier. The ease with which a thyratron field supply could be regulated pointed the way to completely static conversion for both armature and field. The increasing cost of copper and iron has tended to give the static converter an economic

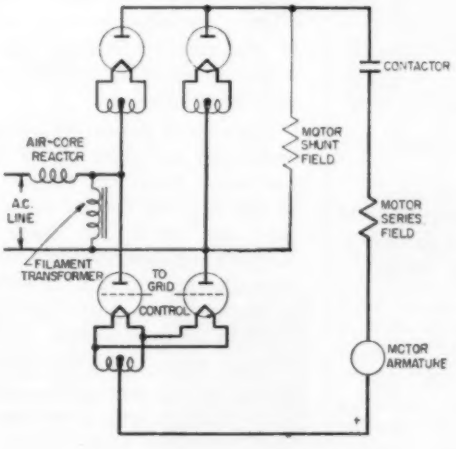

Fig. 1—Bridge circuit for small drives employing two rectifier diodes.

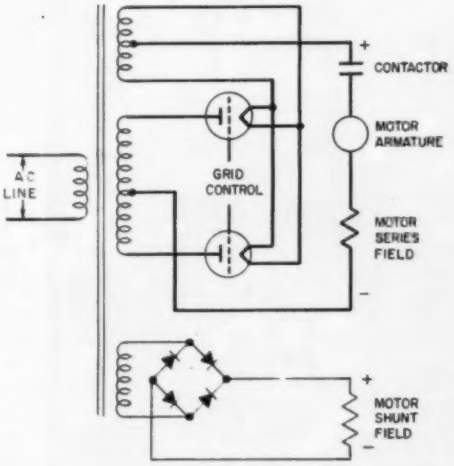

Fig. 2—Comon type of small electronic drive using a center - tapped transformer.

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advantage over the older combination.

Application Advantages: Several factors have led to increasing use of electronic drives.

SPACE AND WEIGHT: The electronic drive today is much lighter and is furnished in smaller cabinets than are comparable rotating drives.

EFFICIENCY: Rotating drives can be made with high efficiencies but at the expense of using extra material. Electronic drives of today are more efficient than their rotating counterparts, achieving as high as 92 per cent conversion efficiency.

STARTING SURGES: An ac motor when started with a contactor across an ac line usually causes considerable voltage dip which affects other equipment. There are no starting transients in an electronic drive.

RESPONSE TIME: Electronic drives have opened a new era of control with the speed of response that is available through their use. Both the physical inertia and the electrical time constant of larger dc generators have made it difficult to control motors for rapid variation in speed or load. Rapid changes in power level are inherently easy to obtain with an electronic drive.

MAINTENANCE: Electronic drives eliminate many of the bearing and brush - maintenance problems. Breakdowns are repaired by part replacement rather than by rewinding. Maintenance is usually no more than keeping the electronic unit clean.

Table 1—Performance Characteristics for Various Control Refinements

Control	Characteristic
Manual grid control.	Wide-range speed control but sensitive low-speed adjustment. Better results with polyphase circuits.
Reference and feedback control operates by matching output voltage against a reference using error signal to call for increase or decrease in rectifier output.	Provides a regulated output voltage. Almost a necessity for single-phase drives and the basis for most drives.
Tailored IR drop compensation is used with the reference and feedback system to maintain motor speed constant with changing loads.	Must be adjusted for a particular motor but gives fair performance over full speed range. Regulation 2 to 5 per cent.
Tachometer feedback and reference systems compensate for all variations within limit of tachometer and reference accuracy.	Capable of most precise speed control; 0.5 per cent speed regulation is common; 0.1 per cent can be obtained.
Acceleration and deceleration control will modify speed change signal to control rate.	Can be used with any type of drive. Is useful where sudden speed change may injure delicate material being processed.
External reference systems control motor speed with reference to a process variable.	Type of drive control depends upon precision to which reference must be met. Customary to use tachometer feedback.

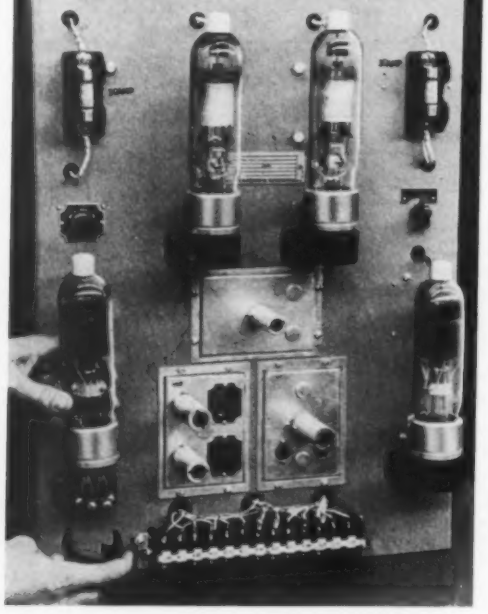

Fig. 3—Typical electronic drive for low-horsepower range incorporating a bridge circuit.

Types of Drives: Thyratrons, ignitrons and Excitrons are currently used in most electronic drives. These three types of power-converting devices can begin conduction when started by a pulse but will not stop conducting until the polarity of the voltage across them changes. They all operate by holding off line voltage until a particular point in the cycle, after which they allow whatever remains of the line voltage to be applied to the motor armature. Since they are all unidirectional devices, they may be combined in such a way that either direct or alternating current may be supplied.

Since all of the drives using grid-controlled rectifiers are so nearly the same, they will mainly differ in the type of control with which they are fitted. In Table 1 the simplest control system has been expanded to indicate the difference in performance with each refinement that can be added.

The smaller electronic drives use thyratrons almost exclusively. Usually built to have a low first cost, they operate from single-phase power and are quite simple in concept. Polyphase drives require more power tubes and more complex grid-control circuits and are seldom used below 5 hp. Between 5 and 15 hp two-phase drives are

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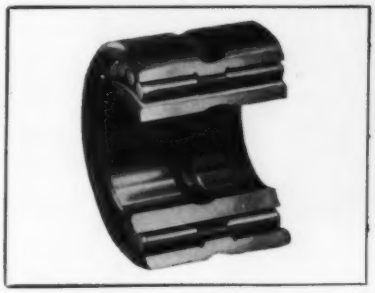

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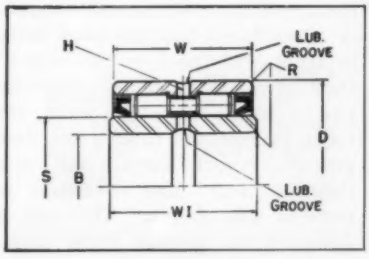

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occasionally used in conjunction with a Scott transformer connection. For smaller drives the bridge circuit, Fig. 1, has been much used. It replaces the circuit shown in Fig. 2 and has been popular chiefly because two rectifier diodes are generally less expensive than a center-tapped transformer. The bridge circuit provides motor-field excitation as part of the power circuit and does not require a separate supply. This circuit has been largely responsible for the large number of electronic drives sold in the low-horsepower range. A recent version of this type of drive is shown in Fig. 3.

The chief advantage of polyphase operation for electronic drives is increased utilization of line voltage. Single-phase drives impose higher peak voltages upon the tubes for a given output voltage and an oversize or special motor may be required to dissipate the extra heat developed by the pulsating direct current. Form factor is the term used to describe this quality and refers to the ratio of rms to dc current supplied. Form factor ranges from 1.4 for a typical single-phase drive to less than 1.01 for a six-phase rectifier drive. Motor commutation is improved with polyphase power so that a completely standard motor may be used when a full-wave three-phase drive is used.

Thyratrons have, in general, been low-current devices. One of the largest commercially available is rated at 18 amp. The absence of larger ratings has meant that a change in drive design was needed between 15 and 40 hp. Ignitrons have been used in this range but have made little impression on the market because their design favors larger horsepowers. The resulting gap in the electronic-drive spectrum has been filled in two ways, by multianode glass-bulb rectifiers in Europe and by the Xatron single-anode grid-controlled rectifier in this country. Since the middle-horsepower range covers the largest segment of the market, it is expected that the electronic drive will make the largest advance in this field.

Ignitrons have enjoyed increased popularity for the higher-horsepower drives in the United States. They have been used in many steel mills and for the operation of large printing presses. In Europe, in addition to the ignitron, many types of multianode and single-anode, steel tank rectifiers have been used. The future for electronic drives in horsepowers between 200 and 10,000 is bright.

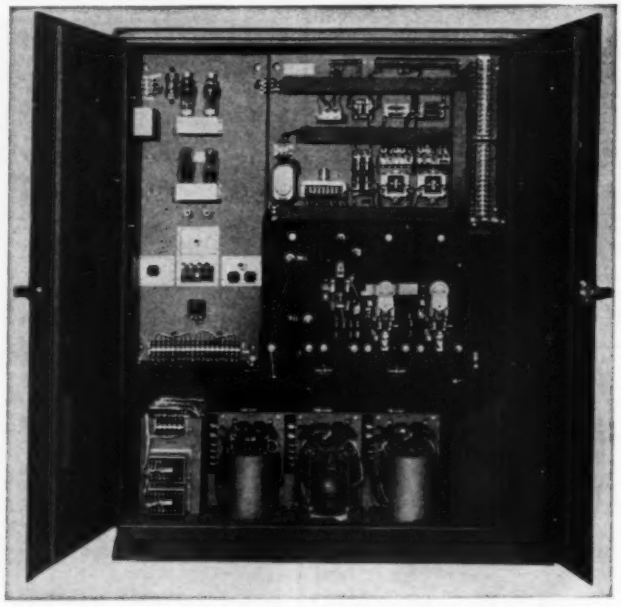

Fig. 4—Xatron drive rated at 100 hp.

The Xatron Drive: The basic ingredients in the Xatron drive as developed at Reliance were the three-phase bridge circuit and a small air-cooled mercury-arc rectifier developed specifically for this application. Two electronic versions of the drive are built, the earlier having armature-voltage control only with manual field control, if desired, and the latter having a single control, to automatically apply armature voltage at full field strength followed by reduction of field strength to get an extended speed range. Both drives are in the "tailored control" category.

Electronic drives lend themselves to repetition of components. This makes for flexibility in manufacturing and in application. All Xatron drives between 30 and 100 hp are housed in a cabinet almost identical to that of a 30-hp rotating drive. Double doors give access to all components both front and back, while a pressure ventilating system keeps components cool and clean with filtered air. The power rectifier tubes are mounted three in front and three in the rear at the bottom of the cabinet. Air-core line reactors directly above the tubes protect the tubes from dangerous current surges and give them a "soft" line conducive to reduced tube faults. The unit is designed to operate from three-phase 440-volt power but may be operated from any line with addition of an appropriate autotransformer. Both 50 and 60-cycle model are built. An illustration of a 100-hp drive is shown in Fig. 4

The range of drive sizes is covered with two ratings of rectifier tube. Nominal current rating of the two tubes are 36 and 60 amp dc. Since these tubes are Excitrons, they must be continuously excited. A pilot arc in each one is maintained by a small dc supply mounted on the panel with the tube itself. The same supply operates

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APPLICATION

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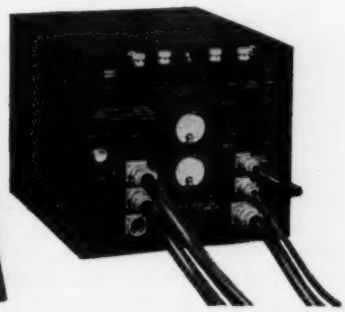

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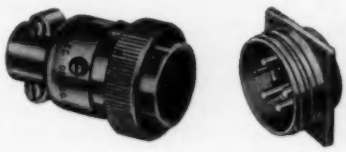

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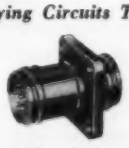

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a magnet which mechanically starts the pilot arc when the unit is turned on.

The power circuit used is the familiar three-phase full-wave bridge. The six mercury-pool rectifiers are controlled by a grid pulse superimposed upon a negative bias. The motor field rectifier is separate from the armature supply and may either be regulated at constant voltage or at constant current. The entire output of the six rectifiers in the armature supply is controlled by the phasing of a single-phase voltage input to the peaking circuit. Since the power needed to fire the pool tubes is approximately 2 watts, a small phase-shift network followed by a vacuum-tube amplifier furnishes ample grid power.

The key to control of the phase shifter is the feedback loop between the grid and cathode of the small vacuum tube which controls a saturable reactor in the phase-shift circuit. The reference voltage, feedback voltage, linear IR-drop signal, nonlinear IR-drop signal, and a line-voltage signal are in series in the loop. Crossing most of the loop is an amplified current signal which will override all other signals to limit maximum current drawn by the motor. Both the voltage-control drive and the voltage and field-control drive have the same type of control. The voltage and field-control drive has a transfer circuit which shifts the reference voltage to the phase-shift circuit for reducing field current in response to a reference signal calling for higher speed.

Performance: Because of the full-wave three-phase bridge circuit, the Xatron drive has fair sensitivity without a great deal of error-signal amplification. A phase shift of 90 electrical degrees will bring the drive from full off to full on. Circuits have been designed to give a drive with a 5 per cent change in speed over an 8-to-1 speed range when load is varied between 10 and 100 per cent of rated load at any preset speed. With a carefully adjusted drive, even better results can be obtained over a short time interval. The basic reference circuit is not designed for precise speed control and there is no correction for motor heating. A current-limit feature is particularly valuable for bringing a motor to a preset speed in the minimum time. Time-limit acceleration and deceleration are standard features of the Xatron drive.

Applications: The electronic drive can be applied to nearly every control problem that a dc motor can overcome. One exception is regeneration. In a regenerating rotating drive the drive motor becomes a generator and pumps power back into the line via the motor-generator set. A rectifier may pump power back into the line only if its polarity is reversed with respect to the source of dc. This means that for inversion either the armature must be reconnected or the motor-field polarity must be reversed. Since both of these alternatives are time consuming, rectifier drives are generally slower in response where this type of control is required.

If the application justifies it, very rapid reversing or slowdown action may be obtained by using two rectifiers connected across the drive motor in opposite polarities. Standard rectifier drives are available with reversing contactors, jogging functions, inching functions, programming and dynamic braking. To help reduce speed, an electronic circuit has been used to bring in the dynamic-braking contactor whenever the reference signal drops a discrete amount below the voltage-feedback signal. This expedient obtains the same type of action as regeneration but does not do it as smoothly.

From a paper entitled "Variable-Speed Electronic Drives for Process Control" presented at the Fifth Annual Industrial Electronics Symposium sponsored by IRE and AIEE, in Cleveland, September, 1956.

Comparing fatigue properties of

Cast and Wrought Steels

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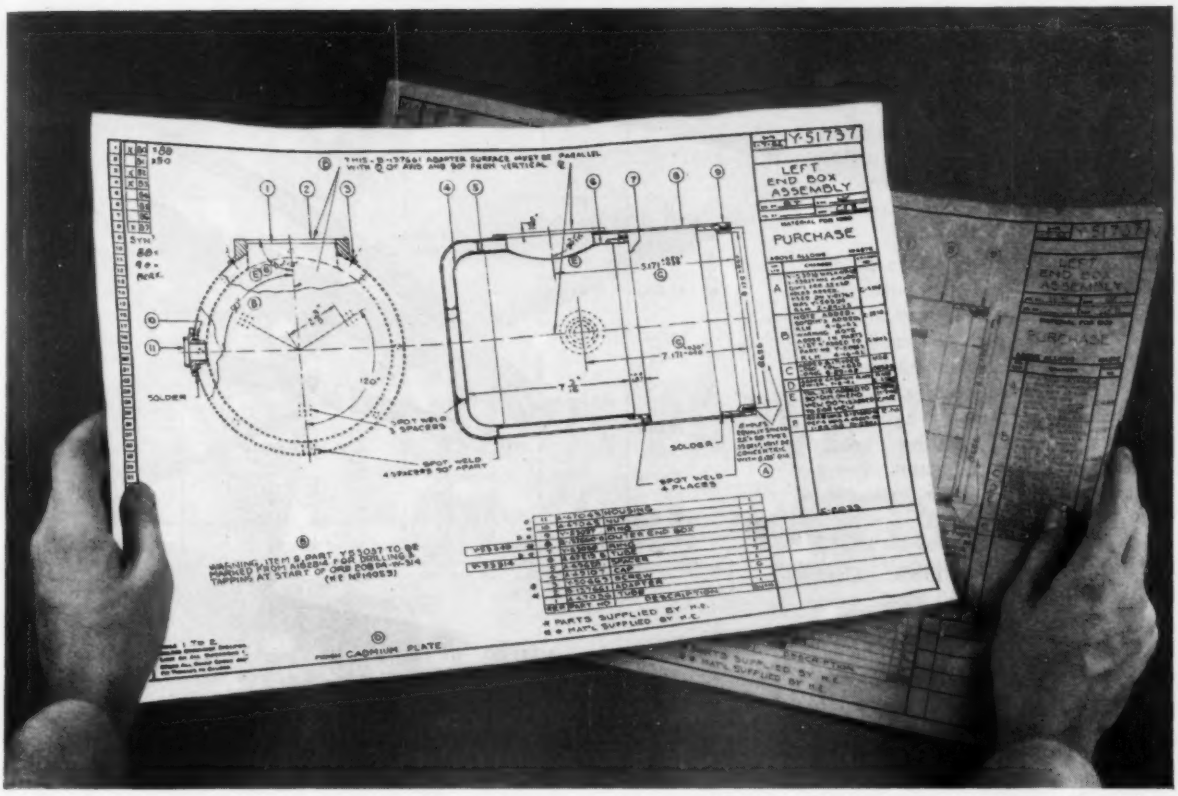
PROMPTED by a lack of much needed data on the relative fatigue properties of cast and wrought steels, the Steel Founders' Society of America recently initiated a research program to develop this information. The work was divided into four main parts covering some of the more common factors which may influence the fatigue performance of standard-carbon and low-alloy steels, both cast and wrought, in the 0.30 to 0.40 per cent carbon range:

1. Effect of steel composition and heat treatment
2. Effect of surface finish
3. Directionality
4. Section-size effect (mass component)

These fatigue studies were carried out with small laboratory fatigue specimens tested in rotary bending, supplemented by tension and hardness tests for all steels.

Effect of Steel Composition and Heat Treatment: A plain-carbon series steel was tested in the annealed and in the normalized-and-tempered condition; four low-alloy series steels were tested in the normalized-and-tempered and in the quenched-and-tempered conditions.

The unnotched endurance limit of any one of the cast steels was about 4/5 the endurance limit of the corresponding wrought steel, Fig. 1. For the plain-carbon series steel the endurance ratio was 0.40



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for the cast steel and 0.48 for the wrought steel. For the four low-alloy series steels the endurance ratio was found to be 0.42 to 0.50 for the cast steels as compared to the 0.55 to 0.60 range for the wrought steels.

With the introduction of a notch, the endurance limit for both cast and wrought material was significantly affected, with the cast steel exhibiting a greater notch resistance. The notched endurance limit for the cast and the wrought steel for any given series and heat treatment was about the same, being 0.27 to 0.32 times their respective tensile strengths, Fig. 1.

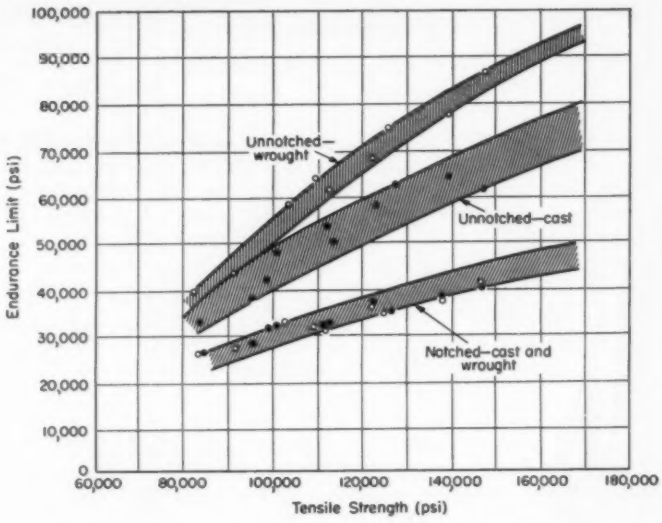

Fig. 1—Variation of endurance limit with tensile strength for comparable cast and wrought steels.

Effect of Surface Finish: Cast 8640 and wrought 8640 steels were tested in the normalized-and-tempered condition. For a polished finish, the endurance ratio for the cast steel (0.45) was about 4/5 that of the wrought steel (0.59); with a lathe-turned finish the endurance ratio for the cast steel was unaffected whereas the ratio for the wrought steel suffered a pronounced decrease to 0.46. Cast-to-shape fatigue specimens tested with an as-cast finish effected a considerable decrease in the fatigue properties, the endurance ratio being lowered to 0.32. This ratio was the same for specimens made with and without risers, thus indicating no effect of centerline shrinkage.

Directionality: With unnotched specimens, the deleterious effect of directionality for a 4-in. round of wrought 4140 steel was shown by a 13 per cent decrease in the endurance ratio from 0.55 for the longitudinal direction to 0.48 for the transverse direction. Data in the literature indicate that this reduction can be as high as 30 per cent for dirty steels. With the introduction of a notch, the endurance limit in both directions was significantly affected. The notched endurance ratio was 0.25 for the longitudinal direction as compared with 0.24 for the transverse direction.

Section-Size Effect: Small unnotched specimens of constant size were taken from various locations in 1¼-in., 3-in. and 6-in. square sections of each of the following cast steels: normalized-and-tempered 1030, normalized-and-tempered 8635, and quenched-and-tempered 8635. The fatigue data were supplemented by regular tensile and Charpy V-notch impact tests at room-temperature.

The distribution curves revealed that for a given steel the endurance limit varied in the same manner as the tensile strength. However, the endurance limit was not dependent solely on the tensile strength. For each of the three steels, the endurance ratio was slightly lowered in passing from the surface to the center of a given section. In addition, the endurance ratio values for the normalized-and-tempered 8635 steel decreased slightly as the section size increased; the other two steels were relatively insensitive to increasing section size. In general, the lowest ratio was obtained at the center of the 6-in. section and the highest ratio at the surface of the 1¼-in. section. This range of minimum to maximum endurance ratio was 0.46 to 0.50 for the 1030 steel, 0.34 to 0.42 for the normalized - and - tempered 8635 steel, and 0.34 to 0.38 for the quenched-and-tempered 8635 steel.

A limited study of the section-size effect for wrought steel was carried out with a 6¼-in. square hot-rolled bloom of C1030 steel. Little change in the fatigue properties was experienced in passing from the surface to the center of the section for a given direction; however, anisotropy was marked. The range of endurance ratios was 0.51 to 0.53 for the longitudinal direction and 0.43 to 0.44 for the transverse direction. The distribution of the endurance ratio of the comparable cast 1030 steel was intermediate to the longitudinal and transverse distributions.

A review of the literature on the section - size effect in fatigue for wrought steel suggested the following:

1. The mass component of this effect had an appreciable damaging influence only in the range of very large sections.

2. The combined mass and geometric components of the size effect may be as high as 40 per cent for large sections.

From a paper entitled "Fatigue Properties of Comparable Cast and Wrought Steels" presented at the ASTM Annual Meeting in Atlantic City, N. J., June, 1956.

Circle 562 on page 19→

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HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Formed Metal Products

How metal fabrications can be produced economically by Hydroforming and Spin-forming techniques for aircraft, automotive, appliance, lighting and industrial applications are shown in illustrated bulletin. 4 pages. Roland Teiner Co.

Circle 401 on page 19

Relief Valves

Photographs, charts and drawings in mechanical data book supplement technical information on installation and maintenance of oil by-pass relief valves. Detailed specifications are included. 12 pages. Fulflo Specialties Co.

Circle 402 on page 19

Copper Clad Sheet

Copper clad laminated plastics for printed circuitry are detailed in technical data book 688. Principles and problems of such circuits are discussed, and advice on proper selection of laminates is given. Various production methods and material properties are covered. 16 pages. Formica Corp.

Circle 403 on page 19

Stainless Steel Wire

Chemical analyses, prices, tolerances, tensile data and gages are among technical data on precision stainless steel wire available in 8-page booklet. Also offered is 4-page folder "What Can You Do With Precision Stainless Steel Wire?" which describes diverse uses. Fort Wayne Metals, Inc.

Circle 404 on page 19

Spray Lubrication Systems

Descriptions of manual and automatic spray lubrication systems for open gearing and slide surfaces are found in illustrated bulletin No. 60-A. Component equipment is also covered. Schematic layouts and application views are used to show operation. 8 pages. Farval Corp.

Circle 405 on page 19

Bellows

Applications, design considerations and standards for Flexon metallic bellows are included in contents of catalog 155. Specific details on using bellows made from various metals, along with pictures, tables and charts, are among contents. 20 pages. Flexonics Corp.

Circle 406 on page 19

Die Casting

Die casting as a means of producing metal parts in zinc, aluminum, magnesium and brass is described in illustrated folder. Company facilities are outlined and typical parts produced are shown. 4 pages. National Lead Co., Doehler-Jarvis Div.

Circle 407 on page 19

Control Transformers

Complete line of G-E control transformers, including autotransformers, machine tool transformers and special application models, is covered in catalog GED-2767. Panel and machine tool voltage regulaltion curves aid selection for a given application. 32 pages. General Electric Co.

Circle 408 on page 19

Shell-Molded Castings

Bulletin 103 describing production service on shell-molded castings lists ferrous and nonferrous alloys handled and shows typical parts produced. Company's facilities, experience and development service are outlined. 2 pages. Crobalt, Inc.

Circle 409 on page 19

Cold-Headed Parts

Seven case-histories of how cold heading cuts costs in manufacturing small parts are pointed up in publication "Hassall Highlights." What the designer should know about cold heading is covered and company history is reviewed. 4 pages. John Hassall, Inc.

Circle 410 on page 19

Thermistors

Thermistors, thermally-sensitive resistors for automatic detection, measurement and control of physical energy, are subject of illustrated manual TH-13A. These units have a large negative temperature coefficient of resistance and respond to minute temperature changes. Complete engineering and design data are given. 52 pages. General Electric Co., Metallurgical Products Dept.

Circle 411 on page 19

Lubricator

Fully automatic type M lubricator which insures precision wrapping of 80 packages per minute for bacon wrapping machine is described in bulletin NB-16. Use of automatic lubrication in a powder press is also pointed out. Other uses and advantages are considered. 4 pages. Bijur Lubricating Corp.

Circle 412 on page 19

Industrial Truck Casters

Forty pages of descriptive material and specification data on all types of Bond industrial casters and wheels, plus a section on hand trucks, drain racks, lift jacks, platforms and dollies are provided in catalog K-40. Ten-pages of facts simplify caster selection. 68 pages. Bond Foundry & Machine Co.

Circle 413 on page 19

Fiber & Laminated Plastic

"Engineering Materials to Improve the Design and Performance of Your Product" is title of folder which lists physical properties and advantages of vulcanized fiber and Phenolite laminated plastic. It also describes company's design and fabricating service. 4 pages. National Vulcanized Fibre Co.

Circle 414 on page 19

Fluorocarbon Products

Forms and properties of wide range of fluorocarbon products, from plastic resins to acids and dielectric fluids, are described in brochure. Types and grades available and their suggested uses are detailed. 8 pages. M. W. Kellogg Co.

Circle 415 on page 19

Single-Phase Motors

Available in ratings through 15 hp, line of PM (Protected Mechanism) all-weather electric motors is described in bulletin 470-A. Various designs are available for normal and high torque service. 4 pages. Robbins & Myers, Inc., Motor Div.

Circle 416 on page 19

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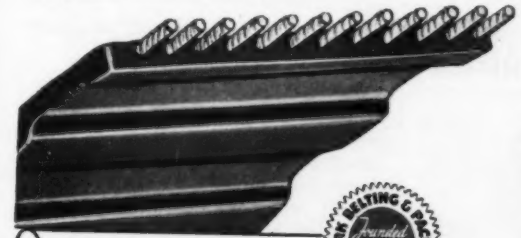

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Circle 563 on page 19

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tating equipment, mills, rolls and drums, Rotherm revolving joints are offered in ½ to 5 in. sizes for pressures to 250 psi and temperatures to 500° F. Full details are given in catalog 12. 8 pages. Rotherm Engineering Co.

Circle 417 on page 19

Thermostats

Cartridge and rectangular types of Thermoswitch controls described in bulletin MC-137 are encased in plastic for service in humid or corrosive environments. Current ratings up to 5 amps, 230 v ac are available. 4 pages. Fenwal Inc.

Circle 418 on page 19

Stainless Steel Wire

Included in descriptive data in illustrated bulletin are analyses, tensile strengths, physical properties and gages of 12 types of stainless steel wire used in manufacture of wire products. Characteristics and suggested end uses are covered. 6 pages. Carpenter Steel Co., Webb Wire Div.

Circle 419 on page 19

Variable Speed Pulleys

Variable speed motor pulleys from ⅛ to ¾-hp, available with adjustable and tilting motor bases, companion sheaves, motor bases and V-belts, are featured in bulletin 1630-B1. Charts list ratings, dimensions and selection data. 8 pages. Worthington Corp.

Circle 420 on page 19

Relief Valves

Important characteristics of recently announced airborne in-line relief valves are discussed in bulletin A5212 and construction features are illustrated with cut-away type drawings. A typical test performance curve is included. 4 pages. Vickers Inc.

Circle 421 on page 19

Power Transmission Couplings

Miniature couplings for servomechanisms, computers and other small power transmission devices are subject of bulletin MC-100. Dimensional drawings appear for units with 3.1, 15 and 50 lb-in. torque capacities. 4 pages. Thomas Flexible Coupling Co.

Circle 422 on page 19

Gearmotors

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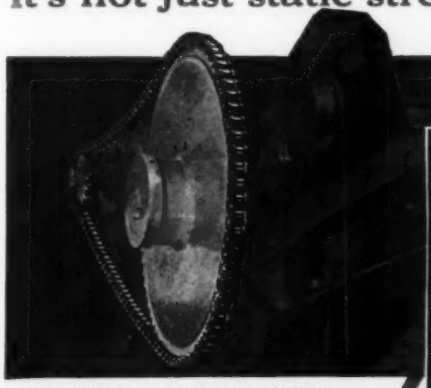

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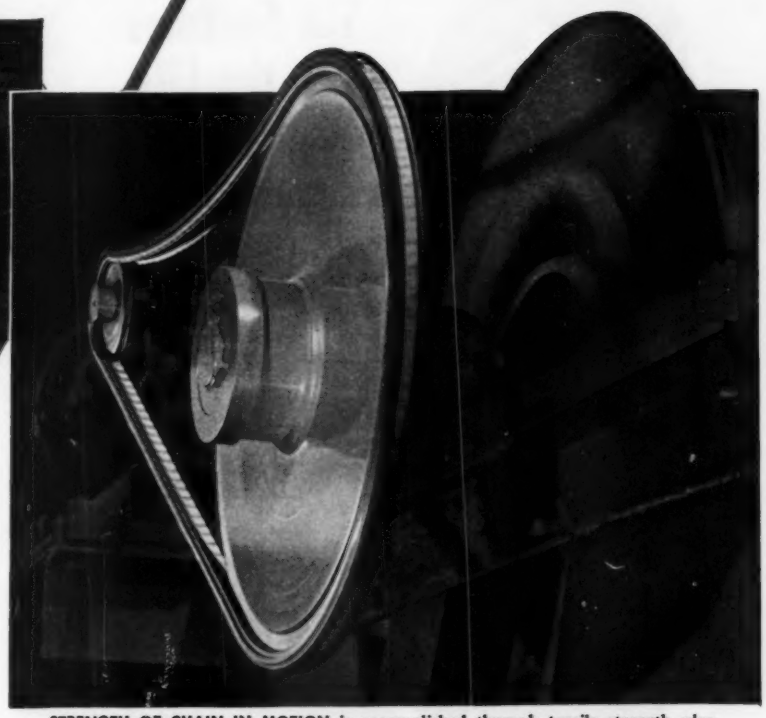

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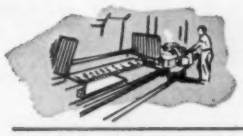

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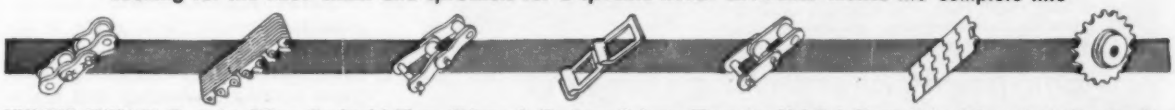

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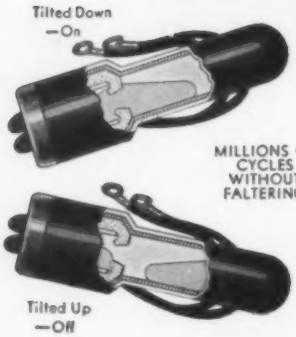

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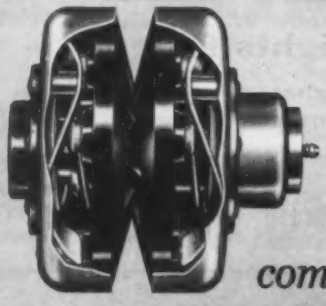

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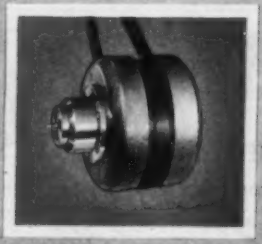

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Circle 567 on page 19

Helpful Literature

shows advantages of gearmotors and lists ratings from 1/3 to 30 hp with gear ratios as high as 10:1. Of interest is a discussion on elliptoidal helical gears and a tooth tempering and hardening graph. 16 pages. U. S. Electrical Motors, Inc.

Circle 423 on page 19

Plastic Gears

Tuners, precision toys, electronic equipment and other mechanisms are typical applications for line of Fastex molded plastic Spiroid gears which offer wide range of product design possibilities. Reduction ratios range from 20:1 to 200:1. Application information is given in bulletin AF-11. 4 pages. Illinois Tool Works, Fastex Div.

Circle 424 on page 19

Pipe Thread Seal

Actual sample of the new Tru-Seal pipe thread seal-fitting is attached to bulletin which explains how to use this fitting which withstands all fluids, temperatures from — 100° to 500° F and most hydraulic pressures. Prices and weights are given for ⅛ to 2½-in. pipe thread sizes. 6 pages. Flick-Reedy Corp., Tru-Seal Div.

Circle 425 on page 19

Plunger Relays

One, two and three pole models are available in line of mercury plunger relays for loads up to 20, 35 and 60 amp. They are adaptable for most electric control applications and utilize hermetically sealed mercury-to-mercury contact principle. Circuit diagrams are included in the "Engineers' File Folder." Ebert Electronics Corp.

Circle 426 on page 19

Speed Reducers

Speed Reducer Engineering Manual B-6727 presents horsepower ratings, torque capacity, overhung load values, dimensions, construction features, installation and maintenance data for single, double and triple reduction units driven by electric motors or gas, oil or diesel engines. 44 pages. Westinghouse Electric Corp.

Circle 427 on page 19

Glass

"L.O.F. Glass for Product and Engineering Design" is a guide to information on window, patterned, plate, safety, bullet resisting, electrical heating, insulating and transparent mirror glass. Charts for specifying each type are included in

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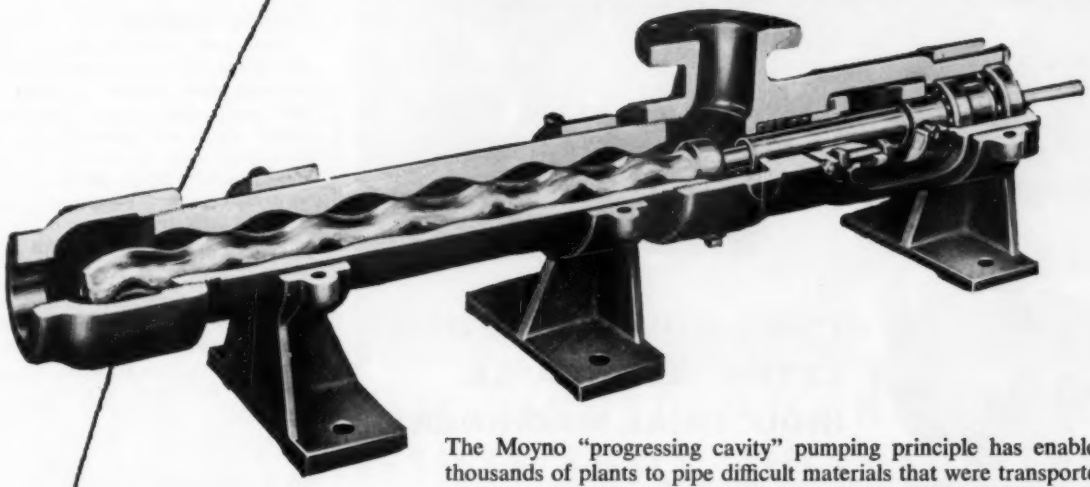

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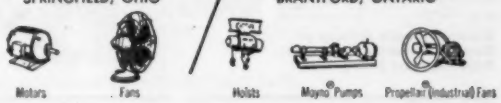

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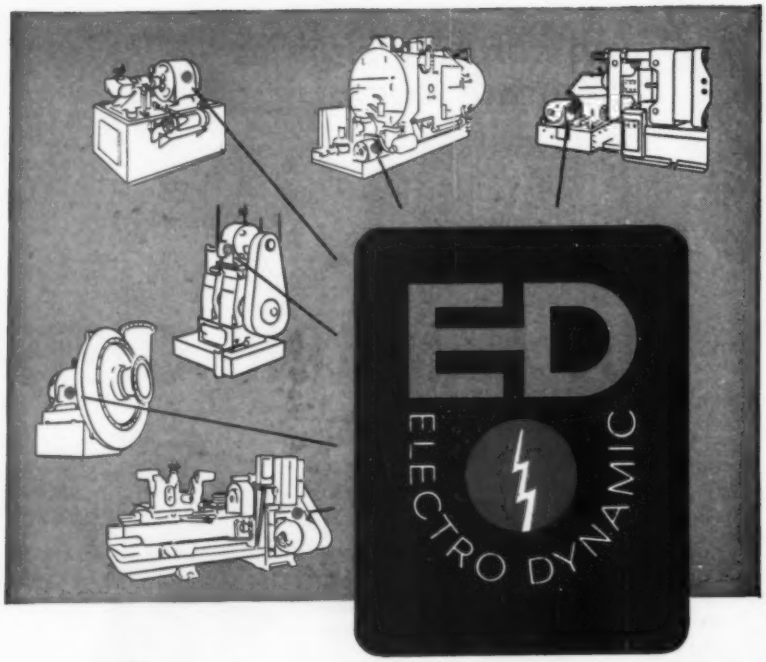
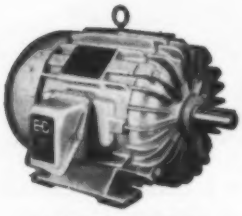
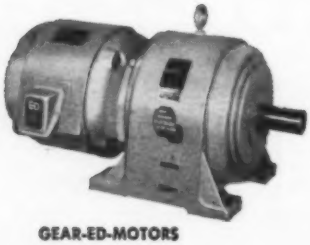




STANDARD MOTORS

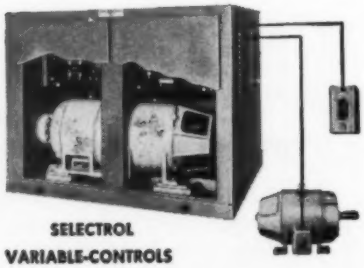
THIS EMBLEM IDENTIFIES EXTRA DEPENDABLE INDUSTRIAL MACHINERY

The red *power spot* on industrial machinery means "Powered by Electro Dynamic." Such machinery relies with confidence on the *extra dependability* of Electro Dynamic motors, the proven industrial motors which give industrial equipment *extra dependable* operation.



GEAR-ED-MOTORS

SELECTRON VARIABLE-CONTROLS



SELECTROL VARIABLE-CONTROLS

NEW...

Write for Brochure 50 and literature on new E.D. motors and drives.

Electro Dynamic division of General Dynamics Corporation Bayonne, New Jersey

GD

ELECTRO DYNAMIC

xtra dependable motors

Helpful Literature

Form SPD-56. 8 pages. Libby-Owens-Ford Glass Co.

Circle 428 on page 19

Torque Converters

Illustrated bulletin 507 gives design and application information on 13,800 series three-stage torque converter in sizes for 40 to 1000-hp loads. Construction and performance data are included. Twin Disc Clutch Co., Hydraulic Div.

Circle 429 on page 19

Flexible Couplings

Wall type chart which can also be folded for filing contains design and selection data on roller chain, Morflex and silent chain flexible couplings. Sizes are available for shaft diameters from ¼ to 4½ in. Chart measures 17 x 22 in. Morse Chain Co.

Circle 430 on page 19

Thermostats

Temperature ranges, ratings, mountings, terminal arrangements and other data on line of Stemco thermostats are outlined in illustrated bulletin 8400. Temperature conversion chart is included. 4 pages. Stevens Mfg. Co.

Circle 431 on page 19

Wire Products

Improved design characteristics of wire, ribbon, weld and Carbostrip products made by Parts Division are featured in illustrated catalog. Wire and ribbon types include alloy, clad and plated. Sylvania Electric Products Inc.

Circle 432 on page 19

Welding Filler Rod

Ampco-Braz No. 3 high-strength manganese bronze filler rod described in bulletin 56L-171 is an all-purpose rod for brazing dissimilar metals, braze-welding heavy cast iron and steel castings, repair of gear teeth and for building up wear and corrosion-resistant parts. Ampco Metal Inc., 1745 S. 38th St., Milwaukee 46, Wis.

Aluminum Hand Forgings

Production of quality aluminum hand forgings is discussed in booklet "Technical Data on Alcoa Hand Forgings." Minimum mechanical properties are listed, and finish allowance, dimensional tolerance and straightness tolerance are illustrated graphically. 16 pages. Write on company letterhead to Aluminum Co. of America, Room 787, Alcoa Bldg., Pittsburgh 19, Pa.

Circle 569 on page 19

Circle 570 on page 19→

DOW CORNING CORPORATION

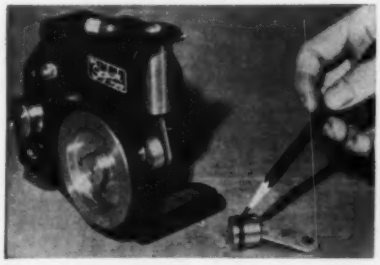
Silicone News

FOR DESIGN ENGINEERS No. 32

Silicone Compound Outlasts Organic Grease as a Lubricant for Rubber

Few, if any, products with moving parts offer absolute dependability and freedom from maintenance. It is significant, however, that many designers are making progress in this direction with Dow Corning Silicones. Take the Skylark Aquarium Pump, produced by W & W Mfg. Co., Cuyahoga Falls, Ohio, for example.

This small pump is designed to continuously aerate water in small aquariums. Originally, organic lubricants were used to keep the Buna N rubber piston ring from drying out and seizing the aluminum piston and brass cylinder. But with even the best organic greases, monthly relubrication was a definite requirement.



Searching for a longer lasting lubricant, W & W finally found the solution in Dow Corning 3 Compound. Chemically inert, 3 Compound greatly prolongs the life of any

(*cont'd pg. 2*)

NEW FLUOROSILICONE RUBBER RESISTS FUELS, OILS, SOLVENTS

A new kind of heat and cold resistant rubber, fluorosilicone rubber, has been developed by Dow Corning research chemists working in conjunction with the Materials Laboratory of Wright Air Development Center. Identified as Silastic LS-53*, this new rubber has outstanding resistance to swelling in contact with jet fuels, gasoline, high aromatic oils and many solvents.

Silastic LS-53 resembles conventional silicone rubbers in that it has comparable tensile strength, ultimate elongation and compression set, and remains rubbery at temperatures from —80 to 400 F. However, the solvent resistance of this new fluorosilicone rubber is far superior to regular silicone rubbers. Typical properties of Silastic LS-53 are outlined in Table I.

*T.M. REG. U.S. PAT. OFF.

TABLE I

Color	**Red**
Specific Gravity	**1.4**
ASTM D676-49T Hardness[1], Shore A Scale	**50**
ASTM D412-51% Tensile Strength[1], psi	**800**
ASTM D412-51T Elongation[1], percent	**250**
ASTM D395-53T, Method B Compression Set[2], percent	**30**
Water Absorption, 70 hr at 212 F Durometer Change	**—2**
Volume Change, percent	**+3**
ASTM D746-54T Brittle Point, degrees Fahrenheit	**—90**

[1] Molded 5 minutes at 260 F; oven cured 24 hours at 300 F.
[2] 22 hours at 300 F

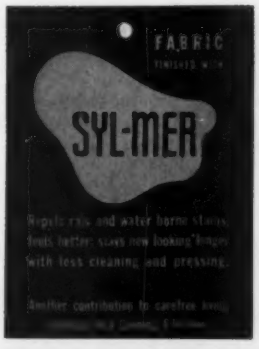
Illustrating resistance to jet fuels, O-rings made of Silastic LS-53 swelled only 20 percent when immersed for 70 hours in an aromatic test fuel at room temperature.

(*cont'd pg. 2*)

DOW CORNING SILICONES PUT NEW SALES APPEAL IN APPAREL

The "design engineers" of the textile industry are now employing Dow Corning Silicones, under the trade name "Syl-mer*," to impart water repellency to fabrics; give them long lasting protection against water-borne stains; and to make the fabrics softer, more luxurious feeling, and highly resistant to wrinkling.

Richman Brothers, for example, are currently offering a large selection of Syl-mer finished suits, slacks and top coats at all of their 106 stores. The Syl-mer process is also being used with excellent results on upholstery fabrics, and many leading furniture manufacturers including Kroehler and Simmons, now feature Syl-mer. *No. 319*



Look for the Syl-mer tag. It's your assurance of Dow Corning quality in silicone finished apparel and upholstery fabrics. *T.M. REG. U.S. PAT. OFF.

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

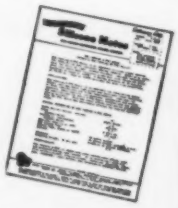
MORE

XUM

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .



"The Effect of High Temperature on the Properties of Organic and Silicone Rubbers," reprinted from RUBBER AGE, contrasts the effects of heat and heat aging on ten types of rubbers, gives a good indication of their respective serviceability at various elevated temperatures. *No. 323*

Antifoam B, a new silicone defoamer, has greater stability than any other water dilutable silicone foam-killer commercially available. Will not separate, oil out, plate out, settle or precipitate in most applications. Retains uniformity and effectiveness even if frozen or boiled. Ready to use, it eliminates need for diluting or pre-mixing. *No. 324*

Reference Guide to Dow Corning Silicones. A comprehensive, 12-page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 325*

"Effects of Radiation on Organopolysiloxanes," a research paper reprinted from Industrial and Engineering Chemistry, describes the effects of secondary radiation from 4 different sources on organopolysiloxanes. Sources include cyclotron radiation, cobalt — 60 gamma, electron, and X-ray. Results indicate that siloxanes containing large amounts of phenyl substitutions may be good construction materials around high energy radiation units. *No. 326*

Dow Corning Release Agents for Plastics are described in a concise, comprehensive data sheet, that describes the forms available and lists typical uses, including concentrations used for a variety of plastics. *No. 327*

Encapsulating Electrical and Electronic Parts with Silastic is the subject of a data sheet that provides details of handling heat-vulcanizable and room-temperature-vulcanizable silicone rubbers in such applications. *No. 328*

Silicone Insulation Eliminates Power Bottlenecks

When the Ohio Valley Electric Corporation designed its new Clifty Creek and Kyger Creek Plants to supply power for the AEC's new Portsmouth (Ohio) Area Project, it specified a 50 C (122 F) ambient and a 70 C (158 F) rise for its twenty-two 1500 hp fan motors. But OVEC also specified that the motors be silicone (Class H) insulated.

When the two plants were put on the line in January 1955, it became evident that their actual generating capacity exceeded design estimates. Ordinarily nothing could be done to take advantage of the extra capacity because plant auxiliaries, such as these fan motors, are restricted to design ratings.

But because the motors are silicone insulated, they easily withstand a boost in operating temperatures from the specified 120 C up to 160 C. This enables OVEC to raise their output from 1500 to 2060 hp. An OVEC engineer made this typical comment, "Silicone insulation helps us obtain maximum output from every plant." *No. 321*

SILICONE COMPOUND *(continued)*

organic rubber, thereby providing long-term lubrication. A thin coating applied to the ring has kept a positive but smoothly operating seal on a test pump for more than 6 months. W & W estimates a single coating of Dow Corning 3 Compound will last an entire year or 12 times the service life of the best organic grease previously used. *No. 320*

FLUOROSILICONE RUBBER *(continued)*

As shown in Table II, one of the best general purpose silicone rubbers swelled over 200 percent under the same condition.

The properties of the new fluorosilicone rubber suggest increased serviceability and reliability for rubber components exposed to extreme heat or cold, and to solvents. Presently limited to use in essential Air Force applications, Silastic LS-53 should also have a wide range of applications in the commercial aircraft, chemical, petroleum, and automobile industries. *No. 322*

TABLE II
SILASTIC LS-53, OIL AND FUEL RESISTANCE[1]

Test Fluid	Silastic LS-53 Vol. Change, %	Silicone Rubber Vol. Change, %
ASTM No. 3 Oil 70 hrs. at 300 F	+ 5	+ 65
ASTM Ref. Fuel B[2] 24 hrs. at 70 F	+20	+225
Jet Engine Oil[3] 70 hrs. at 350 F	+ 5	+30
Hydraulic Fluid[4] 24 hrs. at 160 F	+11	+163

[1] All samples cured 24 hours at 300 F.
[2] MIL-H-3136, Type III. [3] MIL-L-7808.
[4] MIL-O-5606.

Dow Corning Corporation, Dept. 6811, Midland, Michigan

Please send me: 319 320 321 322 323 324 325 326 327 328

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING MIDLAND — *first in silicones* — DOW CORNING SILICONES — CORPORATION MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D.C. (SILVER SPRING, MD.)
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

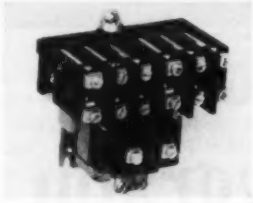
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Machine Tool Relay

multiple-pole unit conserves space

Six-pole in-line 10-amp relay (NEMA Type A1B), for applications such as machine tools and control panels, increases flexibility and conserves panel space by reducing number of extra relays necessary in automatic control systems. Saddle-type terminal permits wiring from four directions with either plain wire or crimped-on terminal connections. Relay is available in standard and latched-in forms. All terminals are ac-



cessible from front of unit and have captive clamps and screws. Rolling motion of contacts assures reliability; permanent air gap eliminates malfunctions resulting from residual magnetism. Relay is available in 2, 3, 4, and 6-pole models in all voltages and frequencies up to 600 v, 60 cycles. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y.

Circle 451 on page 19

Manifold Valve

mounts on sub-plate

Manifold mount control valve in 2, 3, 4, and 5-way types is designed for installations requiring minimum size and speed of removal and reinstallation to insure uninterrupted production. Piping may be installed, connected to manifold plate, and purged before installation of valve. Valve is simply bolted into place on manifold

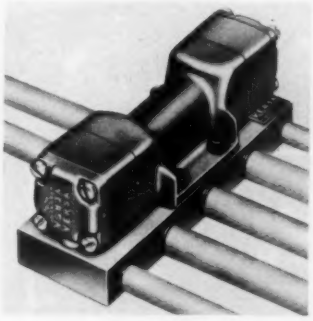


plate. With valve independent of piping, it may be removed for service or replacement without time normally required in disconnecting piping or disassembly of valve. Valve shown is a four-way double pilot unit, but is available with any type of actuating device and for pressures from partial vacuum to 500 psig. Sizes are ⅛-in. to 1 in. NPT. **Versa Products Co. Inc.**, 249 Scholes St., Brooklyn, N. Y.

Circle 452 on page 19

Potentiometer

32-turn unit has resistances to 50,000 ohm

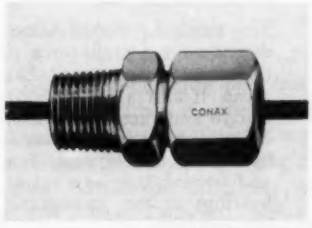
Trimming potentiometer features unusual ruggedness, stability, and long life. Aluminum body and cover are precisely joined to resist warping and twisting under

extreme torsional stresses and for protection against humidity, splashing and dust. Adjustable throughout 32 turns by screwdriver slot, shaft is precision threaded and operates under controlled torque from pressure of plastic friction lock. Accurate adjustments are obtained with precise increments and constant torque throughout adjustable range. With wiper supported on two sides, settings are stable under extreme vibration, acceleration and shock. Case size is 1¼ in. long, ½-in. high, ⅜-in. wide. Weight is ¼-oz. Resistances range from 100 to 50,000 ohm. Resolution (depending on resistance) is 0.2 to 2 per cent. Linearity is 1 per cent. Temperature range is −55 to +125 C. **Aero Electronics Corp.**, 2311 W. Burbank Blvd., Burbank, Calif.

Circle 453 on page 19

Packing Gland

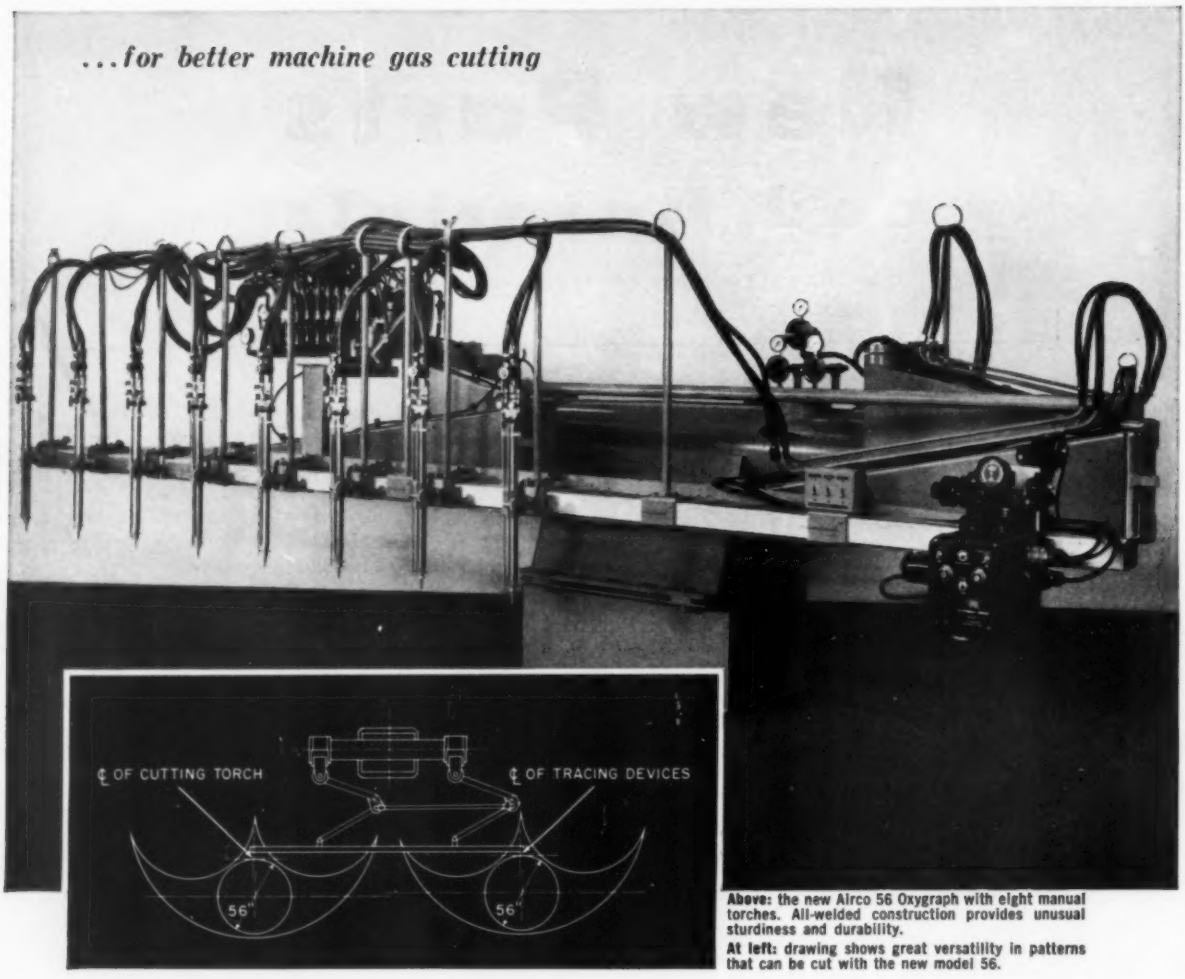
seals to 7500 psi



Midget packing gland, machined from 24ST-4 aluminum or type 303 stainless steel, provides a simple, positive method of sealing wires, tubes, or rods of any material. Bore diameters are 1/16, 3/32, 1/8, and 3/16-in. Sealants (neoprene, lava, Teflon or asbestos-graphite) eliminate any possible damage to material sealed, permitting sealing of ceramic, stainless steel, aluminum, brass and glass materials

XUM

...for better machine gas cutting



Above: the new Airco 56 Oxygraph with eight manual torches. All-welded construction provides unusual sturdiness and durability.

At left: drawing shows great versatility in patterns that can be cut with the new model 56.

NEW...Airco 56 Oxygraph

...for better machine gas cutting of larger work on production schedules

This newly developed Airco 56 Oxygraph meets the demand for a multi-torch oxy-acetylene shape cutting machine that will handle substantially large areas. It *cuts* a *full 56" circle*, and corresponding square and rectangular shapes. Rugged box girder design is used for the pantograph arms, holding vibration to a minimum. Tracer response is smooth and friction-free as a result of large diameter ball bearings in the pantograph hinges and operating bar assembly.

This newest of Airco Oxygraphs will cut an unlimited variety of shapes from steel plates, slabs, billets and forgings. Flexibility of design allows amplifying scope of machine to meet increased shop demands. Tracers are available in four types: electronic, manual, magnetic and spindle. This widened capacity of the new model 56 marks another step forward in welding and cutting progress. For detailed information on the New 56 Oxygraph, write direct to Airco.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND...

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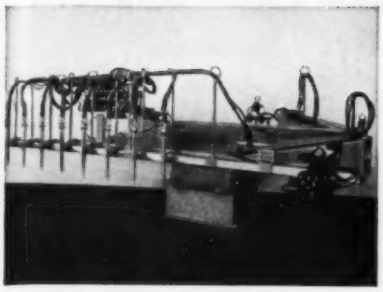


this brand new Model 56 OXYGRAPH

has these exceptional advantages

Cuts a full 56" circle, and corresponding square and rectangular shapes

•

All-welded steel construction for lasting durability

•

Box-girder design of pantograph arms assures efficient operation even with maximum loading of operating bar

•

Reinforced operating bar provides for mounting of torch holders, torches, tracing devices and electrical control equipment

•

Centralized gas control of torches with electrical solenoid valves allows operator to turn on, light and shut off gases without leaving tracing table

•

A maximum of 8 torches can be used, with manual or motorized torch holders

•

A cutting-oxygen ease-on valve, supplied with the machine, is invaluable in making piercing starts

You'll find the new AIRCO 56 Oxygraph a substantial production help in metal shape cutting. For complete details

write direct to

AIRCO

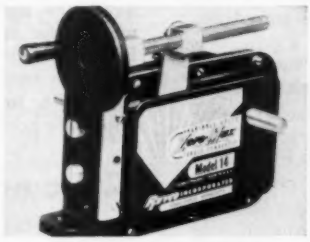
with good fatigue strength, resistance to vibration, and low stress concentration at point of seal. Sealing glands are ½-in. hexagonal by 1⅛ in. long. Operable temperature range is −300 to +1850 F, and pressure range is 500 to 7500 psi, dependent upon sealant. **Conax Corp.**, 7811 Sheridan Drive, Buffalo 21, N. Y.

Circle 454 on page 19

Speed Control

for variable speed reducers

Accurate speed settings and fine speed adjustments of variable speed reducers are obtained readily with sensitive screw control which provides a rotative instead of linear adjustment. In addition to providing positive setting and repeating of speeds, control is easily



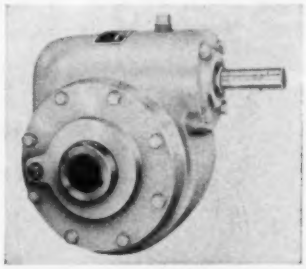
adapted to many types of remote control. Fifty revolutions of screw covers full range of speed from zero to maximum, making calibration for fine speed adjustment simple. There is no vibration within unit and setting will not creep. **Revco Inc.**, 1900 Lyndale Ave. S., Minneapolis 5, Minn.

Circle 455 on page 19

Worm Gear Reducers

shaft mounted units from 1/6 to 7½ hp

Design of these shaft-mounted worm Geareducers incorporates heat-treated aluminum alloy housings which provide high tensile strength, light weight, corrosion resistance and good heat exchange characteristics. Four basic frame sizes are available, with horsepower capacities from 1/6 to 7½ hp and six bore sizes from 1 to 2 in. There are 9 to 15 ratios available in each size; total ratio range is 5:1 to 900:1. Radial-shielded bearings are used on high-speed shafts and tapered roller bearings on low-speed shafts. Wormgears are a high grade of gear bronze. Mechanical lip-type seals are



mounted on shafts which are ground and honed for close finishes. **Electra Motors Inc.**, 1110 N. Lemon St., Anaheim, Calif.

Circle 456 on page 19

Magnetic Filter

traps particles of 2 micron size

Magnetic filter traps ferrous particles of 2 to 3 microns average size with an operating efficiency of 95.5 per cent at rated flow ca-

pacity with low pressure drop. Two models have flow capacity of 12 and 20 gpm. Operating pressure is 5000 psi and proof pressure is 7500 psi. Applications are for servo mechanisms, hydraulic systems and missiles. **Wilkinson Mfg. Co**, Wiltrap Div., Fort Calhoun, Neb.

Circle 457 on page 19

Silicon Diode

has output to 16,000 v

Miniature 16,000 v silicon diode is a series of high-voltage silicon rectifiers designed for power applications where high ambient temperature, reliability, high ef-

(*Continued on Page* 146)

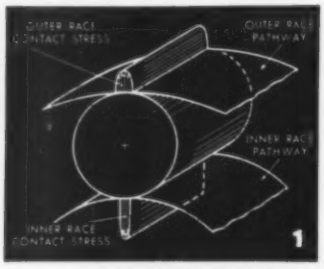
XUM

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT...

Cylindrical Roller Bearing Outer Races

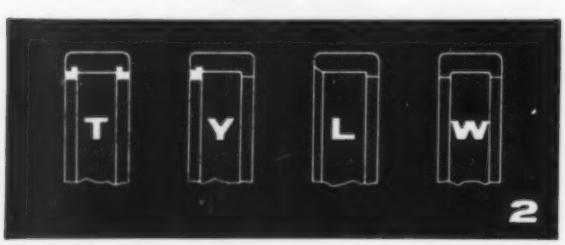
Why they are necessary . . . their importance in relation to bearing versatility . . . wide variety of configurations and locating devices

Outer races are necessary parts of all roller bearings, except in cases where a roller operating surface of suitable hardness and finish can be provided in the housing. In housings of aluminum, cast iron or unheat-treated steel where a hardened and ground surface cannot be obtained by any practical means, outer races are required to assure a fatigue-resistant pathway on which the rollers can operate smoothly.



The outer race is not normally the critical member of a cylindrical roller bearing. This does not mean, however, that outer races cannot suffer fatigue failure. All objects subjected to stress repetitions can fail after a small number of stresses—or may enjoy a surprisingly long life. But experience definitely shows that percentages favor the outer race, and the reason is apparent in Figure 1, which shows a roller engaging both an outer and inner race. Note that the load is spread over a larger area of contact on the outer race, which results in a much smaller maximum stress. This demonstrates in part the principal reason why inner races are the critical member of most cylindrical roller bearings, as explained in one of our previous messages.

Nevertheless, HYATT outer races are manufactured with the same scrupulous care that is applied to inner races and all other components of HYATT Bearings. Outer race performance must match the performance of the rest of the bearing. We consider the fact that the outer race is not the critical member as a safety factor—*not a license to reduce quality.*



1. OUTER RACE TYPES

HYATT Hy-Load outer races are available in a variety of standard configurations for every type of application requirement (Figure 2). The W, L and Y races have solid flanges capable of sustaining light or intermittent thrust loads. The T and Y races are assembled with internal snap rings; they have equal radial load-carrying capacity but are not recommended for applications where a continuous thrust would be taken by the snap rings. The T, Y, L and W races may all be mounted using the roller ends against either the solid shoulder or internal snap ring for purposes of locating the outer race axially.

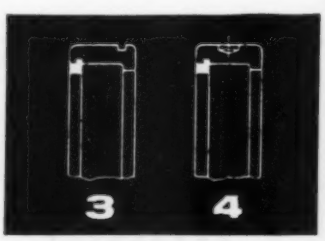
2. CIRCUMFERENTIAL LOCATION

An ample choice of outer race locating methods may be used with HYATT Hy-Loads. Circumferential location is often accomplished by the use of a press fit. (Our general recommendation is that the *rotating* race be applied with a press fit and the *stationary* race be applied with a push fit.) When a push fit is employed, circumferential location is satisfactorily accomplished by axial clamping against the race ends. *Positive* circumferential location is provided by the use of an outer race dowel.

3. AXIAL LOCATION

Axial location of an outer race is conventionally accomplished by pressing or pushing the race to a housing shoulder. The race may be constrained from "walking out" of the housing bore by the flange or snap ring operating against the roller ends. *Positive* axial location is accomplished by axial clamping against a housing shoulder or snap ring.

It may occur, however, that a shoulder is not available in the housing. Under these circumstances, it is necessary to employ an auxiliary holding device such as an external snap ring or an outer race dowel. HYATT Hy-Load Bearings can be supplied to original equipment builders with outer races having a snap ring groove (Figure 3) or a blind dowel hole (Figure 4) at small added cost.



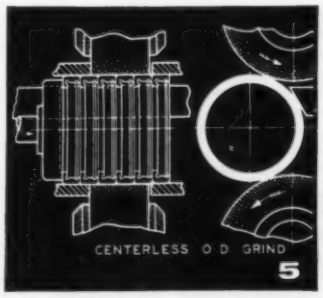
Grinding the flange on a Hyatt outer race.

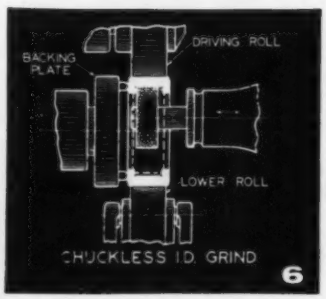
4. OPERATIONAL REQUIREMENTS

Since the outer race is usually the stationary member of the bearing, the exact maintenance of wall variations and runout is not ordinarily critical. However, the outer race *may* be the rotating race in certain applications—so quality controls are rigidly applied to all HYATT outer races to maintain:

a. Minimum wall variation. **b.** Minimum runout of race ends to bore. **c.** Minimum runout of race flange inner faces to bore. **d.** Minimum pathway and outer diameter taper. **e.** Minimum outer diameter tolerance.

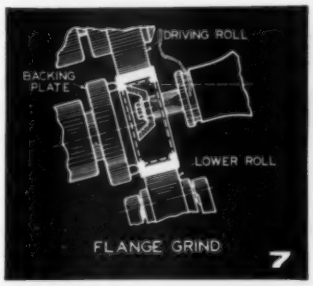
5. MANUFACTURING PROCEDURES





During manufacture, the following sequence of operations provide the controls necessary to generate outer races which meet the strict operational standards maintained by HYATT: After careful primary machining and heat treating, the ends are faced off square and parallel by a double end grind. This provides a reference surface from which all runouts and squareness can be gaged. Outer race diameters are generated by the centerless grinding method to provide an O.D. with as little out-of-round as practical. The through-feed method of grinding represents a valuable economy (Figure 5) to help reduce race costs.

Next, the pathway (or race I.D.) is ground centerless, generating a cylinder concentric with the O.D. cylinder. This is accomplished by driving the race on the O.D. and positioning the grinding wheel relative to the drive roll (Figure 6). Finally, the flanges are ground using the race ends as a reference. The result is a race of as nearly perfect geometry as is practical (Figure 7). It is then critically inspected to insure traditional HYATT dependability and the maximum possible service life.



YOU WILL FIND FURTHER DETAILS in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of roller bearings. Hyatt Bearings Division of General Motors, Harrison, N. J.

GM GENERAL MOTORS

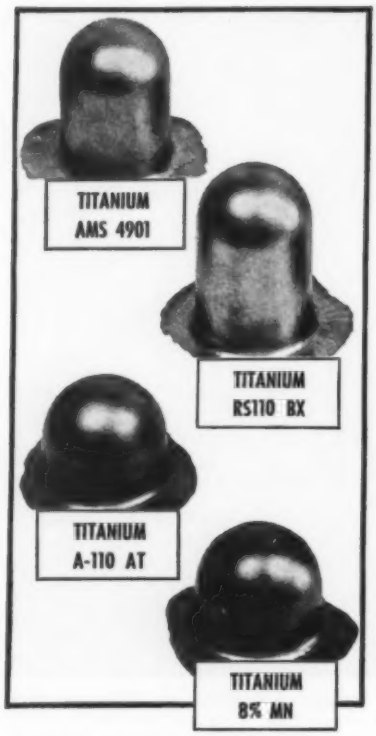
HYATT

HY-ROLL BEARINGS

FOR MODERN INDUSTRY

Circle 572 on page 19

XUM



Titanium Cylinders drawn in one stroke on the same die

Titanium, magnesium, zirconium, stainless and aluminum 2024 are deep drawn in one operation by Brooks & Perkins.

Cost of staging dies and intermediate anneals is eliminated.

. . . Whenever you are faced with a difficult or delicate operation-problem in Magnesium or Titanium, a talk with B&P engineers is well worth while.

Engineering Facilities in Detroit and Los Angeles

. . . Write for Titanium and Magnesium engineering data — also folder on B&P's facilities to handle tough jobs.

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56-C

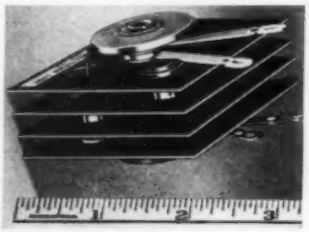
OFFICES IN NEW YORK, WASHINGTON, DALLAS

Circle 573 on page 19

New Parts

(Continued from Page 143)

ficiency and miniaturization are prime requirements. Diode is available in production quantities in range of ratings from 600 v at 100 ma half-wave dc output to 16,000 v PIV at 45 ma for operation within ambient temperature range of −55 to +150 C. Re-



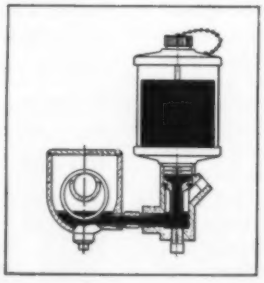
liability, stability, and freedom from contamination is assured by hermetic seal formed by assembling PN junctions in series into a metallized ceramic housing with ferrule type terminals. Applications are for high voltage, low current power supplies in computing machines, magnetic amplifiers, cathode ray tube and radar high voltage supplies and electrostatic precipators. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 458 on page 19

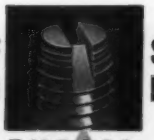
Oiler

maintains constant level

Constant level oilers automatically maintain oil level in ring-oiled and anti-friction bearings, gear boxes, pump housings and similar applications. Operation is based on



liquid seal principle. When oil level in the bearing recedes due to oil consumption the liquid seal on the internal spout of the oiler is temporarily broken. This allows air from the air intake to enter the reservoir, releasing oil until the seal is restored. Oilers are refilled

SELF TAPPING  SELF LOCKING

PHEOLL

SCHWEPPE STUDS

Patents Pending

CUT COSTS

1 ELIMINATE TAPPING
2 HOLD TIGHTER
3 CAN BE 'AUTOMATED'

WHEREVER a stud is specified, you can profitably cut production time and cost with self-tapping, self-locking Schweppe Studs. They also can replace bolts to advantage on many applications.

WHAT ARE SCHWEPPE STUDS?

They are double-ended studs made with dual thread-cutting slots at the lower end. Final threads on this end develop a positive frictional interference locking action on entering the hole.

HOW ARE THEY DRIVEN?

Schweppe Studs can be driven in an inexpensive *drilled* hole with any power stud driver. In one simple, continuous operation, they cut their own thread, drive, lock and seal.

WHAT ARE THEIR ADVANTAGES?

The *self-tapping* feature eliminates tapping time and thread inspection, tap wear and replacement, tap breakage and salvage time. The *self-locking* action of Schweppe Studs prevents loosening or backing out, even under extreme conditions.

WHAT ABOUT AUTOMATION?

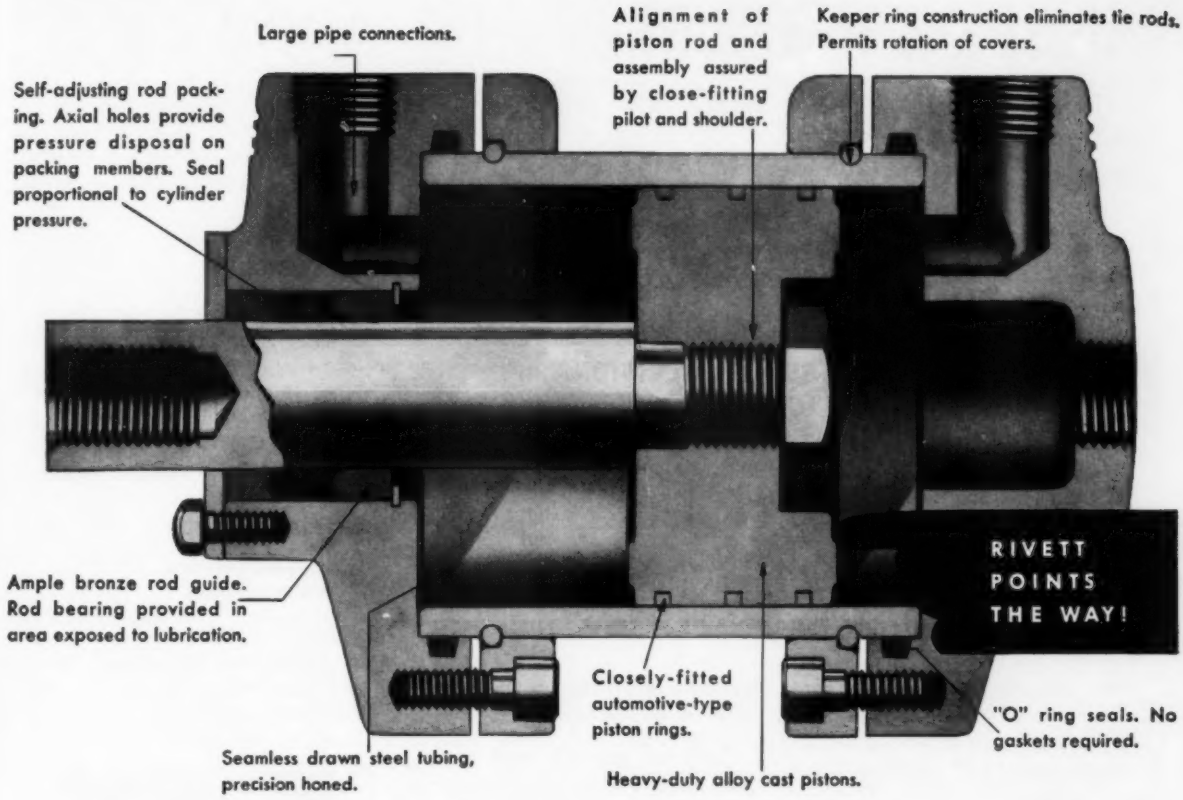
Since Schweppe Studs may be located accurately from the slotted end, they can be "hopperized" for automatic feeding and driving.

• To fit many applications, Pheoll Schweppe Studs can be furnished in a broad range of metals, finishes, sizes and thread styles. Learn how you can profit . . . find out about the many advantages . . .

Write for free Bulletin 1056

PHEOLL MANUFACTURING COMPANY
SCREWS • BOLTS • NUTS
5706 Roosevelt Road, Chicago 50, Ill.

Circle 574 on page 19


Large pipe connections.
Alignment of piston rod and assembly assured by close-fitting pilot and shoulder.
Keeper ring construction eliminates tie rods. Permits rotation of covers.
Self-adjusting rod packing. Axial holes provide pressure disposal on packing members. Seal proportional to cylinder pressure.
RIVETT POINTS THE WAY!
Ample bronze rod guide. Rod bearing provided in area exposed to lubrication.
Closely-fitted automotive-type piston rings.
"O" ring seals. No gaskets required.
Seamless drawn steel tubing, precision honed.
Heavy-duty alloy cast pistons.

Sealing efficiency improves with increased pressure in Rivett 1500 PSI* Cylinders!

*Higher on application.

- External "O" Rings Act As Static Seals To Eliminate Gaskets And Assure LEAKPROOF OPERATION!
- Automotive Type Piston Rings Reduce Friction, Increase Sealing Ability, Permit Sensitive Response To Any Pressure.
- Keeper Ring Construction Eliminates Tie Rods.
- Self-Adjusting Rod Packing Cuts Friction.
- Unfailing Power For Millions Of Cycles.

1080 SELECTIONS!

7 mountings; 10 bores; standard and 2:1 over-size rod; single and double end rods; internal or external thread; cushioning either or both ends; special covers.

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Brighton 35, Boston, Mass.

Get Catalog No. 106 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

Member National Fluid Power Association

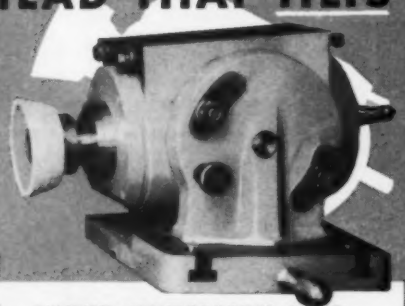
THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

RIVETT
"100"
HYDRAULIC CYLINDERS

XUM

HERE'S A HEAD THAT TILTS

and Yours Will Nod, Too When You See What You Can Do With This One



POPE SUPER PRECISION 1 HP, 3600 RPM MOTORIZED TOOL AND CUTTER GRINDER CLEARANCE ANGLE SWIVELLING HEAD

With Angular Adjustment In A Vertical Plane

Give this versatile head the nod and save time and money these seven ways:

1. You can use cup wheels for practically all clearance angles and thus produce a cutting edge on tools that lasts longer because it is stronger.

2. You can keep the tooth rest on the center line of the cutter for practically all grinding on centers or in the work head.

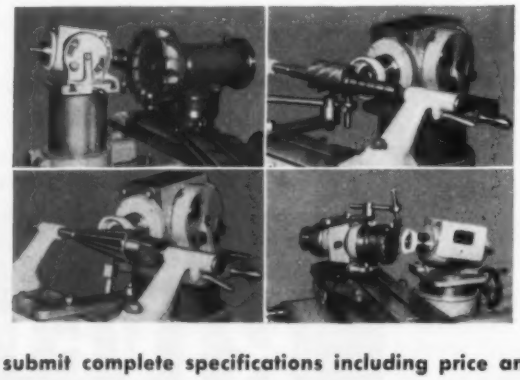
3. You can grind most cutters and reamers all over *with a single set-up* using the swivelling table and Pope tilting head.

4. You can read all clearance angles directly in degrees from the scale provided on the head. No more mistakes.

5. You can get the right clearance angle on such tough grinding jobs as slab mills, taper reamers, angular cutters and form tools.

6. You have one safe speed—3600 RPM—for all wheels generally used on cutter grinders. Heat checking of cutters is virtually eliminated.

7. You have a head that's so easy to adjust and use it saves you time and money every time you grind a tool.



No. 101

Ask us to submit complete specifications including price and delivery.

Specify POPE PRECISION SPINDLES

POPE MACHINERY CORPORATION

Established 1920

301 RIVER STREET · HAVERHILL, MASSACHUSETTS

Circle 576 on page 19

New Parts

through a top filler cap, a seal holding the oil supply in the reservoir while the cap is removed. Large air intake permits a filter to be inserted or the intake can be piped to top of bearing housing to equalize pressure differential or prevent dust entry. Reservoirs are transparent to allow visual checking of supply and condition of oil. Four models have capacity range from 2½ to 18 oz. All pipe connections are ¼-in. NPT. **Oil-Rite Corp.**, 2318 Waldo Blvd., Manitowoc, Wis.

Circle 459 on page 19

Instrument Knob

two-part unit has 1500 variations

Variety of types, sizes and colors of instrument knob heads may be combined with a number of various types and lengths of stems, giving large variety of knobs from small

basic stock of standard parts. Fifteen different knob-head sizes in ten colors may be combined with ten different stems, giving total combination of 1500 different varieties of knobs. **Colman Tool & Machine Co.**, Amarillo, Tex.

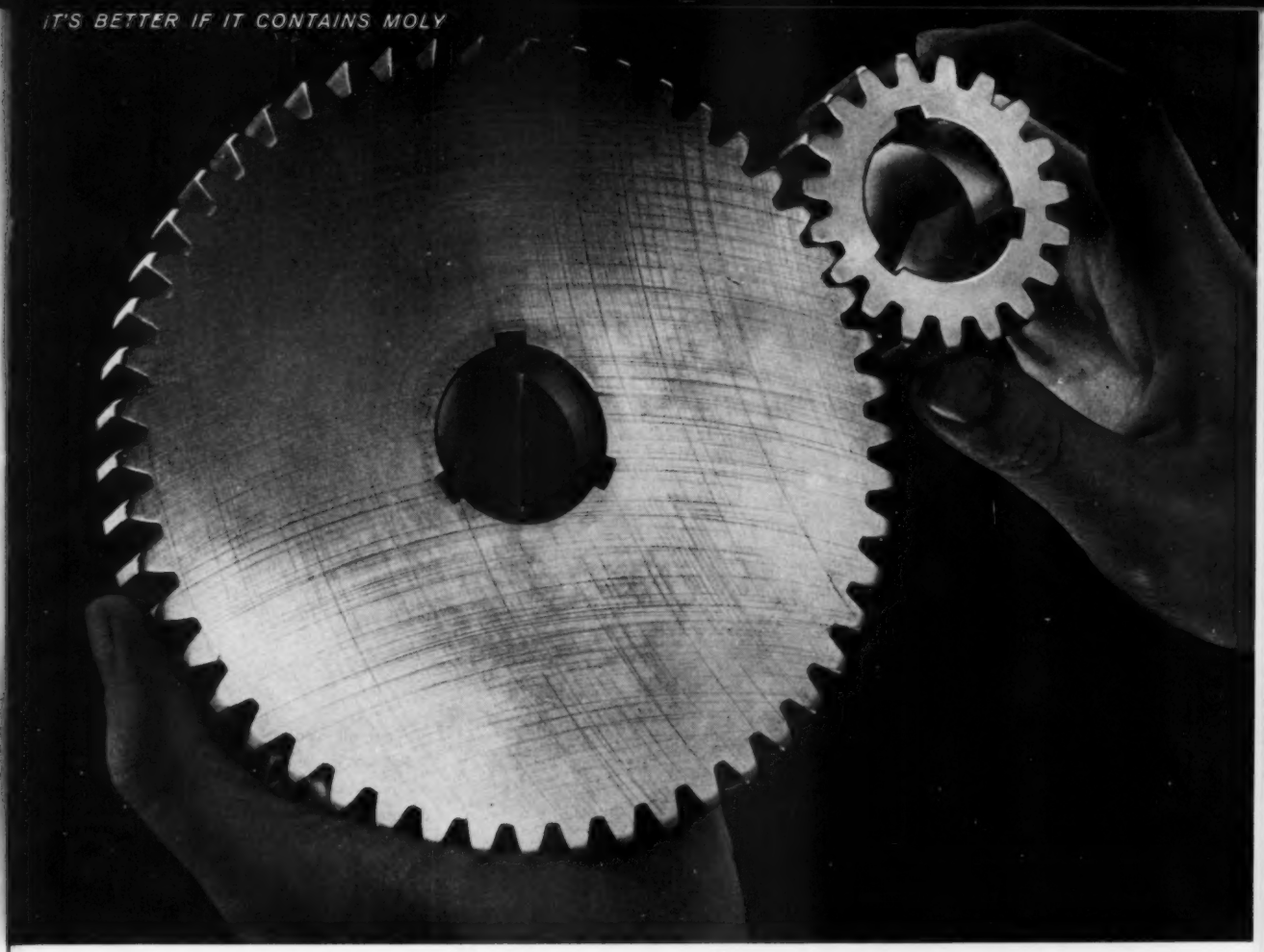
Circle 460 on page 19

Strippable Coating

protects surfaces from marring

Strippable coating, called Strip-Kote, is a high solids content plastic emulsion which, when dry, gives a tough transparent film for protecting metal finishes, plastic, porcelain and glass surfaces from marring or scratching. Applied by brush or spray gun, film becomes transparent as it dries. Dried film is permanently flexible and is easily stripped from surface. Containing no inflammable solvents, coating has a solids content of 52

IT'S BETTER IF IT CONTAINS MOLY



Up to 1% Moly in carburizing steels gives required hardenability economically

Why limit the use of molybdenum to the .15/.25% Mo and .20/.30% Mo contents of the traditional grades? For the contributions of moly do not stop there. Laboratory tests and production runs prove that as molybdenum contents increase up to 1%, hardness increases progressively. A wide range of case and core hardenabilities, therefore, can be obtained – economically, too.

Tests with a series of molybdenum-manganese steels show that these compositions give higher case hardness on a direct quench than other steels of comparable core hardenability. One extensively tested composition, for example, is 0.5% Mo – 0.5% Mn steel. It shows longer life, and is lower in cost than steels previously used. And it produces a higher case hardness with similar or less distortion. What's more, tool life and surface finish are equal or better. Good reasons why several companies have already adopted this grade for automotive gears and other critical applications.

If you use carburizing steels, see what a higher molybdenum content can do for you. Part of the story is contained in the technical article "New Carburizing Steels For Critical Gearing." For your copy, or other technical data, write Climax Molybdenum Co., Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM

Circle 577 on page 19

XUM

Are Your Designs Really Complete?

The design of equipment should cover all factors—and one of the most important is the lubrication. Complete the design with a lubricant engineered by Anderol to meet the special demands of the product:

- **Temperature Range**
- **Corrosion Resistance**
- **Load Capacity**
- **Rust Protection**
- **Lifetime Lubrication**

Regardless of volume or requirements, Lehigh will engineer a special Anderol synthetic lubricant to do the job.

WRITE TODAY:

For samples, complete data, and government specifications. Our laboratories are at your service. Write Dept. 13.

ANDEROL
ENGINEERED LUBRICANTS
Lehigh Chemical Company
CHESTERTOWN, MARYLAND

Circle 578 on page 19

New Parts

percent. Coverage varies according to film thickness, but averages 500 sq ft per gal for 0.004-in. (4 mil) film thickness. **Chemical Consulting Service,** 3711 S. Clement Ave., Milwaukee, Wisc.

Circle 461 on page 19

Time Delay Relays

have range from 0.1 second to 15 minutes

Time delay relays for applications requiring frequent time adjustments have graduated dial head. Four time ranges are available: 0.1 to 3 seconds, 0.1 to 10 seconds, 10 seconds to 2 minutes, and 30 seconds to 15 minutes. Each relay

is adjustable within its range in one revolution of the dial. Units consist of a pneumatic timing head, solenoid assembly, switch, coil and terminals. Relays are relatively unaffected by temperature changes within range of −65 to +160 F. Available for continuous or intermittent dc service, voltage ratings are 6 to 550 ac, 60 cycle and 25 cycle, and 6 to 230 v dc. **Elastic Stop Nut Corp. of America, A'G'A** Div., Elizabeth, N. J.

Circle 462 on page 19

Plastic Valve

handles highly corrosive liquids

Polyvinyl chloride valve operates under temperatures and pressures too severe for other plastic materials. Valve operates at up to 170 psi continuous duty, and at lower pressures will operate safely at temperatures to 170 F. Unit has excellent corrosion resistance, flow characteristics, and immunity to electrolysis and galvanic action. Valve is available in two basic types: needle and globe. Needle

REMEMBER WHEN?

The oil soaked streak down the middle of every road . . . the oil puddle on the garage floor . . . busted shafts and burned bearings due to lost lubrication?

Universal Oil Seals changed that picture . . . solved these problems efficiently and economically. There's a Universal seal to fit YOUR requirements too. Over twenty-six years of specialized oil seal engineering at your service.

We invite your inquiry.

UNIVERSAL OIL SEAL CO.
P.O. BOX 74
PONTIAC 12, MICH.

Circle 579 on page 19

Here is an entirely new series of clutches combining, in a single compact unit, all of the PROVED advantages of MAXITORQ Floating Disc Clutch design with an exceptionally simple, powerful, and dependable electro-magnetic actuating mechanism.

As will be seen from the illustration, the new clutches use standard proved MAXITORQ Disc-Pacs, quickly and easily replaced. The electro-magnetic unit is enclosed in a stationary housing, permitting direct wiring connection. When energized, the magnetic coil acts through an armature plate and sleeve to exert pressure on the clutch discs. Pressure, however, is maintained entirely by the magnetic flux, without mechanical contact between moving and stationary parts.

This unique design permits instant, positive engagement or disengagement, with the additional possibility of precisely controlling torque for a gradual pick-up or release of load. In addition to meeting standard clutch and brake installation requirements, MAXITORQ Electric Clutches open up new possibilities in application to fully automated equipment and for remote control.

Standard sizes, single and double types, are available for either wet or dry operation to transmit up to 788 lb. ft. of torque, operating on 110V–AC rectified to 90V–DC.

Complete details sent on request. Write Dept. MD-11.

- **PROVED** performance.
- **COMPACT** design.
- **FLOATING** neutral . . . no drag.
- **POSITIVE** engagement.
- **STATIONARY** coil . . . no brushes.
- **NO ADJUSTMENT.**
- **WET OR DRY** operation.
- **FULL** power transmission.
- **FULL** range of sizes, types.

THE CARLYLE JOHNSON MACHINE COMPANY

MANCHESTER, CONNECTICUT

9C.J56

XUM

You name them... we can't

Here are two carbon-graphite parts recently manufactured for use in the production of nuclear energy. What are they? We don't know. We only know that these parts have gone to work somewhere to make atomic power possible.

Carbon-graphite may be the answer to some of your more difficult engineering problems. Its many unique properties often simplify mechanical design. To name a few: It is inert, non-contaminating. Self-lubricating. Heat resistant. Non-corrosive. It can be formed into intricate shapes and can be machined to close tolerances.

If you have an engineering problem, discuss it with our engineers. Our many years and broad experience in producing carbon and carbon-graphite products for industry may help you find the *best* solution.

50th ANNIVERSARY 1906 · 1956

Morganite INCORPORATED

Manufacturers of fine carbon-graphite products for fifty years.
3314 48th Avenue, Long Island City 1, New York

New Parts

valve is graduated similar to a micrometer with an indicating point on handle to allow specific setting to be obtained and repeated accurately. Globe valve has seating

disk of non-sticking Teflon, opening and closing with light pressure. Non-rising stem utilizes double-lead thread to move from full open to full close in three turns. Both valves may be used as straight-through or right-angle units. Sizes are ⅛ and ¼-in. NPT and ⅛, ¼, and ⅜-in. od male tube. **Chemtrol Corp.**, 11008 Santa Fe Ave., Lynwood, Calif.

Circle 463 on page 19

Commutation Switch

withstands impact shocks of 15 *g*

Motor-driven commutation switch embodies precision workmanship, superior signal characteristics and long life expectancy. Switch has two rings of contacts and multiple connector leads, brought to a

standard AN connector for easy installation. Brush size and type, duty cycle and general configuration are standard, but some modification of circuitry is possible. Switch operates under adverse conditions, meeting specifications requiring ambient temperature range of −65 to +160 F and operation at 75,000 ft altitude. Vi-

MONARCAST* ALUMINUM PERMANENT MOLD CASTINGS OFFER WIDER FINISHING LATITUDE

Plus

MORE CASTING VALUE PER DOLLAR

Product appeal is enhanced, functional value improved, through the wide range of finishes available on Monarcast* aluminum permanent mold castings. These intriguing finishes offer new freedom of design and engineering while simplifying purchasing procedures.

Monarch operates the largest completely owned finishing division in the permanent mold industry. Custom designed automatic equipment speeds mass-production, guarantees uniform quality. End-costs and rejects are lowered through elimination of multiple finishing responsibilities.

Monarch's "non-competitive" experience in both aluminum permanent mold and aluminum and certified zinc die casting offer you factual answers on the right method to obtain highest quality at lowest end-cost.

Casserole: Sales stimulating Spectraglaze,* colorful porcelain enamel exterior, accented by high polish trim.

Built-in grill: High polish Velvaglaze*.

Waffle baker: Velvaglaze* highlights product appeal, produces mar and heat resistant cooking surface.

Electric Fry Pan: Catches vogue of color-in-the-kitchen with easy-to-clean Spectraglaze* and polished finish.

*Velvaglaze, Spectraglaze and Monarcast are Trade Marks of

MONARCH ALUMINUM MFG. COMPANY—9205 DETROIT AVENUE—CLEVELAND 2, OHIO—OLympic 1-1700

MANUFACTURERS OF: *Aluminum Permanent Mold Castings • Zinc Die Castings • Aluminum Die Castings • Exclusive Velvaglaze Finishing • and Spectraglaze, colorful Porcelain Enamel on Aluminum Permanent Mold Castings.*

XUM

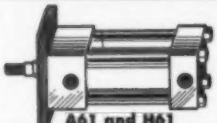
over 8,000 Different Cylinder SELECTIONS—

Miller AIR AND HYDRAULIC CYLINDERS AND BOOSTERS "IN STOCK" for immediate delivery

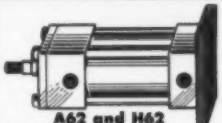
See Miller Bulletins A-105K (Air) and H-104K (Hydraulic) for Complete Dimensions and Engineering Data on these "in-stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 feet.

"IN-STOCK" MODELS

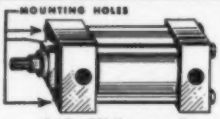
"A" Signifies Miller 200 psi Air Cylinders; "H", 2000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.



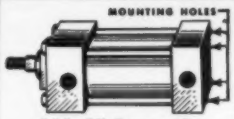
A61 and H61
Flange Mounting on Rod End
(A61 not available in 8" bore)



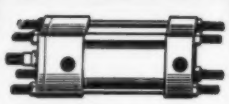
A62 and H62
Flange Mounting on Cap End
(A62 not available in 8" bore)



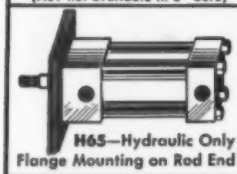
A63—8" Bore only
Flange Mounting on Rod End



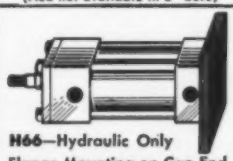
A64—8" Bore only
Flange Mounting on Cap End



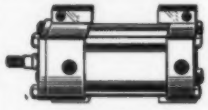
A50 & H50—Tie Rods not extended beyond nuts.
A51 & H51—Tie Rods extended both ends (shown).
A52 & H52—Tie Rods extended. Cap End only.
A53 & H53—Tie Rods Extended. Rod End only.
A54 & H54—Two Tie Rods extended at both ends.



H65—Hydraulic Only
Flange Mounting on Rod End

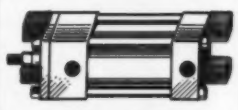


H66—Hydraulic Only
Flange Mounting on Cap End

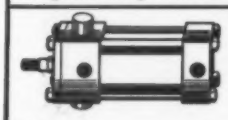


A72 and H72
Side Lug Mounting

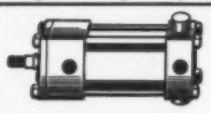
A74 and H74
Side Flush Mounting



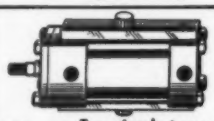
A77 and H77
Side or Foot Mounting



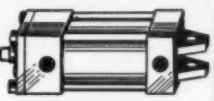
A81 and H81 Trunnion Mounting on Rod End



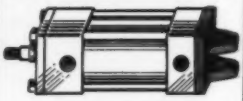
A82 and H82 Trunnion Mounting on Cap End



A83 and H83 Trunnion between Head and Cap
(one week delivery)



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

IN STOCK BORES in Inches — "IN-STOCK" STROKES (in Inches)

	Bores	Rod Dia.	Rod Turn Down & Threads																				
AIR	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12							
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12							
	2	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	6	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	8	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
HYDRAULIC	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
	2	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1¾"	1¼-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	2"	1½-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36

(1) (2) (3) (4)

"A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

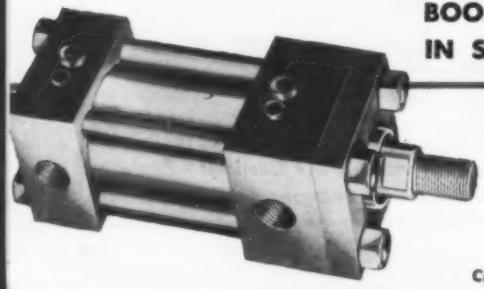
Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.



BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBA8, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.

Write For Catalog and Stock Price List

Miller

Circle 583 on page 19

MILLER FLUID POWER DIVISION
FLICK-REEDY CORP.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

XUM

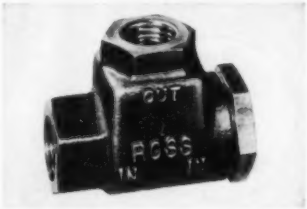
bration tolerance at 500 cps is 10 *g*; minimum life is 100 hours continuous operation without cleaning or adjustment. Power supply is 115 v, 380 to 520 cps, single phase. Nominal speed at 400 cps is 5 rps. Noise level is below 50 millivolts. **Mycalex Electronics Corp.**, Clifton, N. J.

Circle 464 on page 19

Shuttle Valve

lightweight unit handles air or liquids

Shuttle valve in ¼-in. and ⅜-in. pipe sizes has dimensions of 1¼ by 2⅜-in. With two inlets and one outlet, brass unit can be used



for air and certain types of liquids. Weighing only 14 oz, valve has differential sealing pressure of 15 psi and operating pressure of 15 to 125 psi. Temperature range is up to 175 F. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit 1, Mich.

Circle 465 on page 19

Control Panel

for hydraulic circuits is sub-plate mounted

Sub-plate mounted traverse and feed panel for control of industrial oil-hydraulic systems is suited for application on a wide variety of machine tools and production equipment. Available in a broad selection of models to meet system requirements, unit is designed for use with ¾-in. pipe, and operating pressures to 1000 psi. Both conventional and differential cylinder traverse action models are available. Differential model is used with cylinders having rod area equal to approximately one-half piston area for obtaining fast traverse rates with small pumps. Either open or closed center main valve spools is available. Flow control valve section includes two

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Bunting capability and leadership in the field of Cast Bronze Bearings and parts are well established and widely recognized. Today Bunting offers an equally comprehensive and responsible service in the field of Sintered Powdered Metal Bearings and parts.

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Circle 584 on page 19

Choosing the carbon brushes that are supremely suited to your requirements is easy when you have the book that tells you all about brush characteristics and applications. Covering brushes for every type of fractional horsepower, automotive, aviation and industrial application, it represents 50 years of carbon and brush leadership. Its title? "Brushes by Speer."

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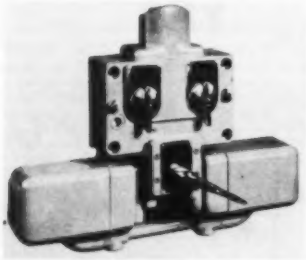
City_____ State_____

Circle 585 on page 19

New Parts

locking type dials which permit independent selection of both fine and coarse feed rates. Adjustment of both rates is infinitely variable within range and can be



made during operation. Transition from rapid advance through coarse feed, fine feed and stop or dwell is obtained without blind or dead spots between phases. Phases may be initiated by manual, mechanical, electrical or hydraulic actuation of main spool. **Vickers Inc.**, Box 302, Detroit 32, Mich.

Circle 466 on page 19

Synthetic Rubber

provides barrier to chemical corrosion

Synthetic rubber, known as Ameripol SN, is equal or superior to crude rubber as a barrier to chemical corrosion. Resistance to concentrated hydrochloric is same as crude rubber; material forms the hard continuous surface film that is necessary in linings for this service. Tests comparing the synthetic with crude rubber included runs on lining and immersion tests with many acids and corrosive liquids for which crude rubber is recommended. In each case, the synthetic performed as well or better than the crude rubber. **B. F. Goodrich Industrial Products Co.**, Akron, Ohio.

Circle 467 on page 19

Speed Reducer

shaft-mounted unit offers ratios to 8000 to 1

Differential speed reducer pulley is a V-belt unit having an internal gear reduction ranging up to 8000 to 1 and a torque disk designed for driving through a separate control motor to provide differential action. Torque disk, with held

Through the years, our trade mark has become a mark of quality that stands for the simplicity, efficiency and dependability of Curtis Universal Joints . . . the Hallmark of the industry.

In a wide range of applications, Curtis Joints offer the designer assurance of long life and trouble-free performance — because they are quality-controlled at each step of manufacture.

CURTIS UNIVERSAL JOINTS

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- Complete equipment for government tests

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UNIVERSAL JOINT CO., INC.

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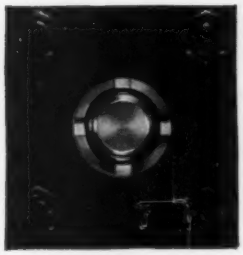
As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 586 on page 19



Here are the world's finest power cylinders

...competitively priced!

This ad is written for the man who has thought all cylinders are "pretty much alike." That just isn't so, and your Hannifin man would like an opportunity to show you why...

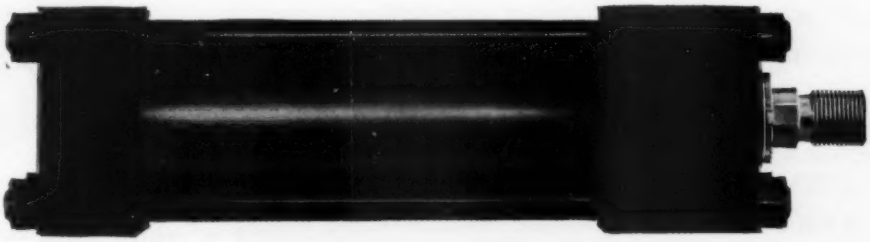
He'll show you design features that other cylinders simply do not have... extra quality workmanship at critical points that pays off in longer life ...accessibility that simplifies their infrequent maintenance. And when he talks price and delivery, you will find these better features cost you no more, can often be delivered sooner.

We think you'll agree that it pays to standardize on Hannifin cylinders.

AIR AND HYDRAULIC

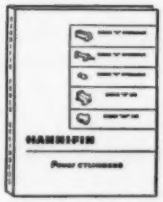
HANNIFIN

POWER CYLINDERS

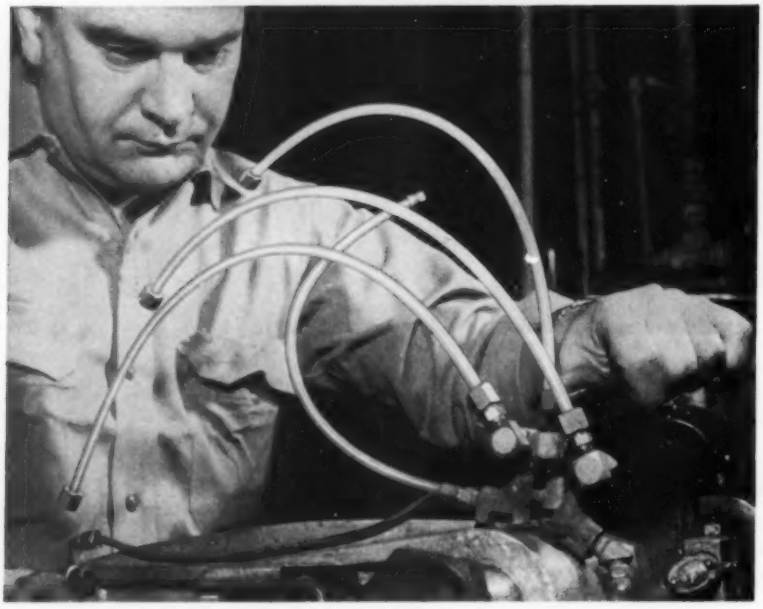


COMPLETE CYLINDER FILE

Write for your copy of this new Hannifin Cylinder File . . . complete, easy-to-use, easy-to-order-from information on five lines of Hannifin Cylinders. Write Hannifin Corporation, 515 S. Wolf Road, Des Plaines, Ill.



PRESSURE **NYLAFLOW**® TUBING



High-strength, flexible *Nylaflow* simplifies installation problems

● No other tubing material offers the same combination of desirable properties for oil and lubrication lines, air lines, food and beverage lines, vacuum lines, etc.

● Nylaflow Pressure Tubing *is* different. It's made from a tough, horn-like polyamide, with these superior advantages:

ALMOST UNLIMITED FLEX LIFE—minimum fatigue from vibration and continuous flexing.

HIGH STRENGTH—highest strength per weight ratio of any extruded plastic tubing with corresponding high burst strength.

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PERMANENT FORMING—lines can be pre-bent to permanent position.

● Nylaflow is processed under the most rigid controls to assure highest quality and absolute uniformity. It is available in short-time burst pressures of 1000 psi. and 2500 psi. and in a variety of sizes and coil lengths. Write today for latest test and application data or information on how Nylaflow can solve your tubing problem.

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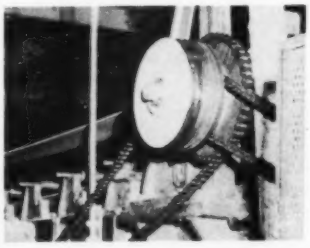
POLYPENCO Nylon, Teflon†, Q-200.5 (cross-linked polystyrene) and K-51 (chlorinated polymer)

†DU PONT TRADEMARK

New Parts

gear attached, is in a fixed position. As pulley revolves around held gear, reduction is obtained through internal planetary gear train. Driving torque disk and



held gear by attached sprocket provides differential action at any desired controlled speed. It can be arranged for either chain or V-belt drive, and can be driven in either direction. Shaft mounted, unit requires no mounting brackets or bearings. Unit may be adapted to either reduce or increase speed. **Hart Reduction Pulley Co.**, 426 W. Main St., Waukesha, Wis.

Circle 468 on page 19

Hydraulic Motor

accelerates to full speed in 0.003 sec

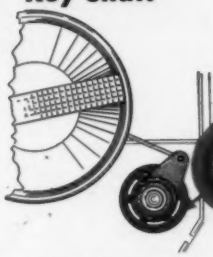
Constant displacement axial-pis-type hydraulic motor is designed for operation in systems of aircraft and industrial applications requiring high performance at pressures to 3000 psi. Instant response

motor is available in a range of eight sizes from 0.1 through 1.0 cu in. displacement. Suitable for continuous, intermittent or continuously reversing duty cycles, motor may be stalled indefinitely without damage. In reversing service, rotation is determined by direction of flow through motor. Nine-cylinder motor employs valve pistons placed in same bore with driving piston and delivers approximately 180 deg of power per

5 Waldes Truarc Rings simplify assembly, eliminate parts, bring big over-all savings to new design low-cost camera

Anscoflex II Camera

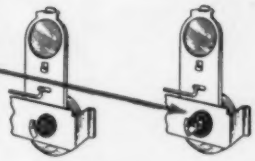
Key Shaft



Parts originally designed for self-locking Truarc ring (series 5105). Some cameras in the past had brass cup staked to the body. At times staking operation cracked the plastic, resulting in loss of expensive part.

Portrait and Filter Lens Knob Assemblies

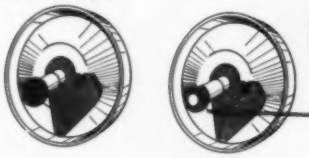
Old way: Knob with plastic shaft used washer and heat forming operation that flattened the plastic pin and locked the pivot in position.



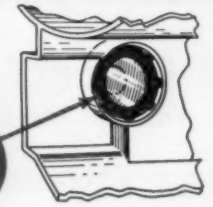
Truarc way: Molded plastic knob with pin is easily and quickly held by a Truarc self-locking ring (series 5105). No groove is necessary. Washer is eliminated and it is possible to remove ring if necessary without damage to knob.

Winding Knob

Old way: With screw and washer design, it was necessary to disassemble entire camera to remove screw which secured winding knob. Self-tapping screw sometimes failed to secure knob, produced excessive end play.



Truarc way: Truarc "E" ring (series 5133) allows removal of winding knob without major disassembly of camera, reducing repair time. Use of stacked rings and Truarc applicator saved $10.40 per M on labor. Material saving: $2.29 per M.

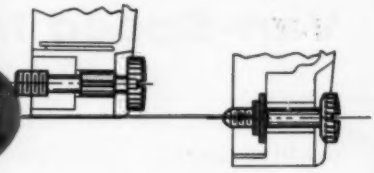


Rear Lens

Parts originally designed for self-locking Truarc ring (series 5005) Some cameras in the past had glass element secured by heat forming tabs from plastic body. Loose or chipped elements resulted in loss of both parts.

Flash-Gun Case Assembly

Old way: In the original design a sleeve was wrapped around neck of screw and pressed into hole of plastic cover. Close working areas made assembly difficult and required extra operation to lock ring into place.



Truarc way: Series 5133 E-Ring snaps onto unthreaded shank of screw quickly, needs no special groove. Labor saving $7.06/M.

Ansco, Binghamton, N. Y., uses the latest technical advances in construction to produce an economical, easy-to-use reflex camera. 5 Waldes Truarc Rings are used in this new design to save material and labor costs, eliminate parts, simplify assembly and reduce rejects.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

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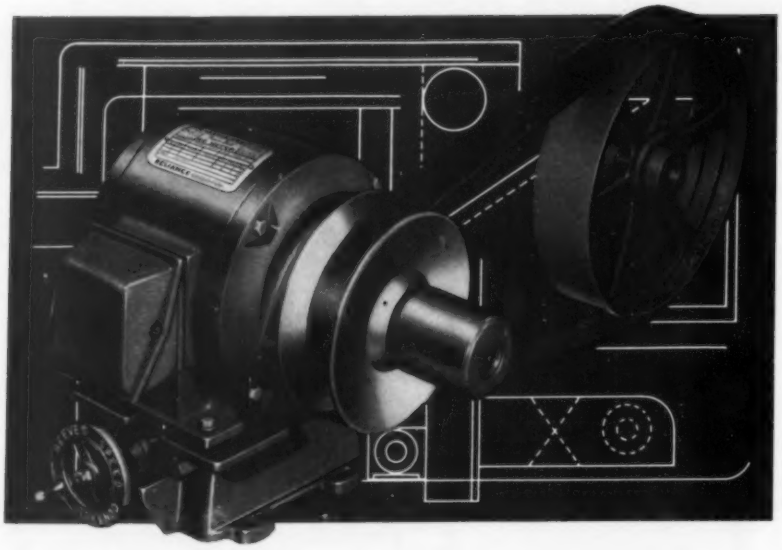
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

XUM

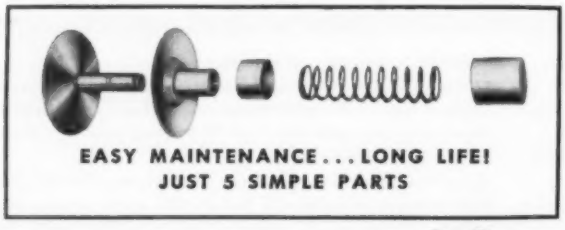
Insure machine designs against early obsolescence



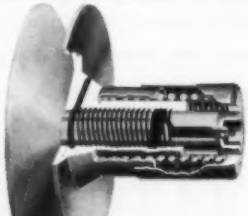
REEVES

Vari-Speed Motor Pulley

A compact, low-cost variable speed drive that widens machine range . . . adds flexibility. Fourteen models for ⅛ to 15 hp; 1.75:1 to 4:1 speed ratio.



REEVES "Close-grooving" —a special lubrication system—insures free sliding disc for easy speed changes.



For bulletin complete with rating charts and dimensions, write Dept. H21b-V545.

REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
Columbus, Indiana

New Parts

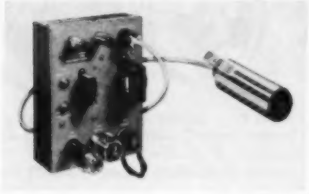
cylinder revolution. Hydraulic load in motor is absorbed in tension by shaft, avoiding need for thrust bearings. Motor features high acceleration. On 0.6 cu in. per revolution motor, acceleration is 1.35 x 10^5 radians per sec^2 at 3000 psi. Acceleration time is 0.00078 sec per 1000 rpm, or 0.0003 sec to bring motor to maximum speed. Motor starts with 15 psi pressure drop and runs with 10 psi pressure drop under no-load conditions. **New York Air Brake Co.**, Watertown Div., Watertown, N. Y.

Circle 469 on page 19

Limit Switch

operates without physical contact

Proximity limit switch converts mechanical position or motion into an electrical signal without physical contact between part (of ferrous magnetic material) and switch. Available with either re-



lay output or tube output, switch operates on 110 v ac. Relay type has output capacity of 5 amp, and electronic type has sufficient capacity to energize a small control relay. Switch may be operated by small parts, fast moving parts, and parts with rough edges. Unit will sense large parts at distances up to 1½ in. from transducer head, and very small parts at 1 in. distance. **Square D Co.**, 4041 N. Richards St., Milwaukee, Wis.

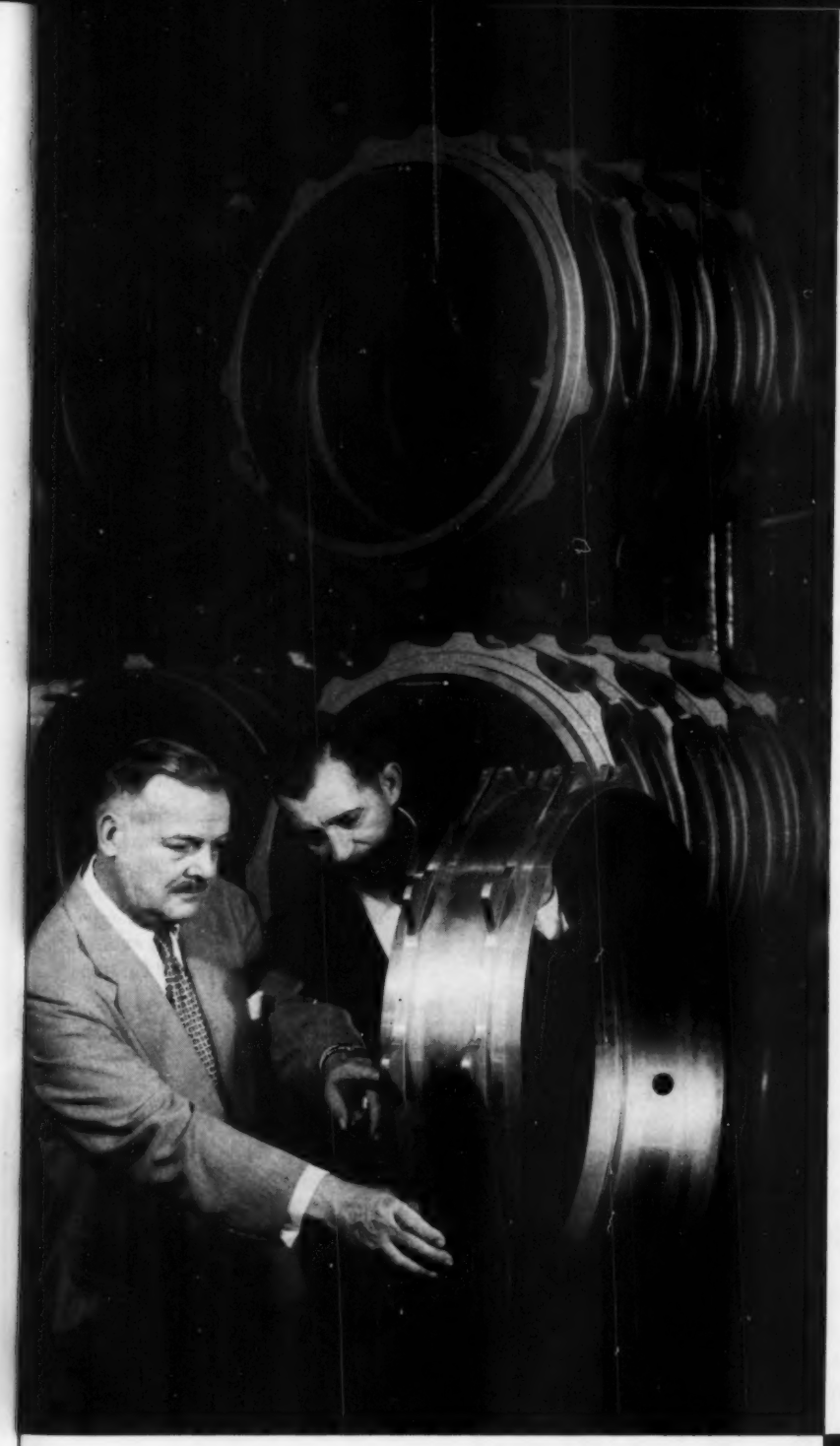
Circle 470 on page 19

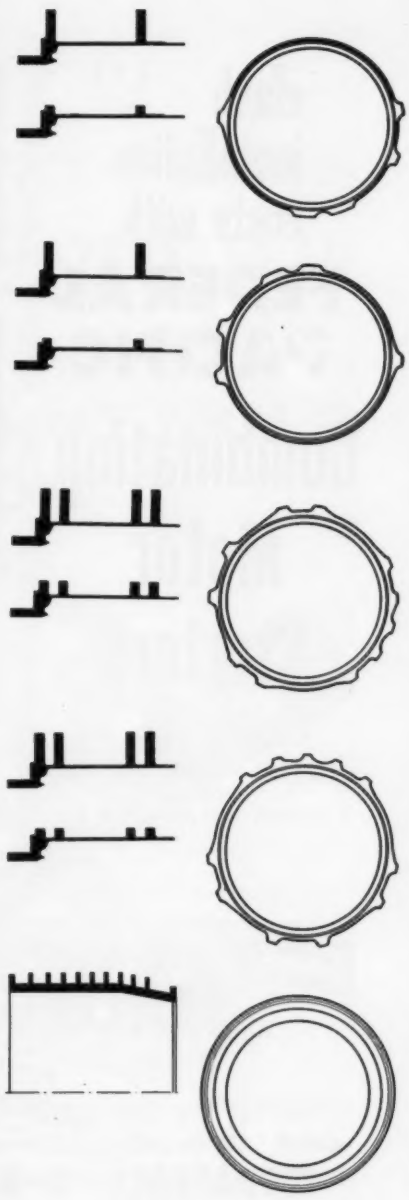
Universal Joint

double unit is operable to 90 deg

Double universal joint for slow speed applications (to 300 rpm) has precision ground forks of alloy steel, manufactured to concentricity tolerance of 0.001-in. Pins and center blocks are of hardened

Circle 590 on page 19





Typical ring sections and profiles showing lug configurations in a smaller scale.

STAINLESS STATOR RINGS

One of Cameron's most interesting contributions to military and commercial air-power today is the production of forged, stainless steel, stator rings. Our unique processes make possible precision forgings with odd lug configurations, large diameters and a vastly superior grain structure. Shapes and sizes heretofore costly to produce as a forging are now sound economy at Cameron.

The study of specialized alloys to meet the extreme demands of today and to anticipate those of tomorrow parallels forging production and is a part of our progress.

Investigate these advantages — write or call . . . . .

Circle 591 on page 19

Cameron

IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

XUM

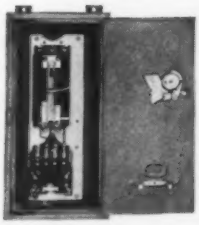
slash installation costs with

FEDERAL PACIFIC

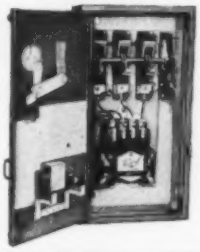
Combination Motor Starters

Finest Products Engineered

FEDERAL PACIFIC ELECTRIC COMPANY
50 Paris Street, Newark 1, N. J.



THERMAL MAGNETIC CIRCUIT BREAKER permits harmless temporary overloads; trips instantly when overload becomes dangerous... offers quick-make, quick-break action, thermal tripping element and deionization arc quenchers.



DISCONNECT SWITCH designed for cool operation, safety and long life. Features clear visibility, positive circuit opening and silver plated current carrying parts.

NOW Federal Pacific does away with the need for separate motor controls and safety switches or circuit breakers! Now you can meet all your needs with one simple space-saving device... and save money while you do it! You install only one device—save valuable time—conserve precious space! Faster, easier installation more than offsets the slightly additional cost.

Circle 592 on page 19

Specify JOB-RIGHT SEALING

DEVELOPED BY GOSHEN RUBBER

TETRASEALS

RECTANGULAR SECTION RINGS

High performance, economical static seals, TETRASEALS are equal in quality to, and interchangeable with, standard O-rings. Available in natural, synthetic and silicone compounds to meet MIL, AMS, SAE, ASTM and industrial specifications.

O-RINGS of SILICONE RUBBERS HAVING SAME SHRINKAGE AS ORGANIC RUBBERS

Now, dimensions and tolerances of AN, MS, SAE, JIC and NAS met consistently with standard tooling from compounds useful over a temperature range of −80°F to +500°F. Non-toxic, too. Lower unit costs, fewer rejects, faster delivery, are other advantages.

For more details, ask for free literature on TETRASEALS and O-RINGS.

other EXCLUSIVE Goshen Rubber DEVELOPMENTS

GORSYN

Synthetic rubbers (not silicones) that remain flexible in temperature ranges of −65°F to +300°F; and −20°F to +400°F.

GORSIL

Silicone rubber compounds for molded, lathe-cut and metal-bonded products that must withstand −100°F to +500°F temperatures.

GORLUBE

Low-friction treatment, for O-rings and parts made of natural, synthetic, and silicone rubbers.

GORBOND

Process for securely bonding rubber parts to metals of most every kind.

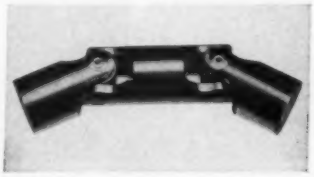
See our catalog in Sweet's Product Design File

Goshen Rubber Co. INC.
CUSTOM DEVELOPMENT AND FABRICATION SINCE 1916
1711-6 S. TENTH ST. GOSHEN, IND.

Circle 593 on page 19

New Parts

alloy steels, ground to similar tolerances. Available in 13 sizes, joint has range from ½-hp to 207 hp at 100 rpm, and static torque from



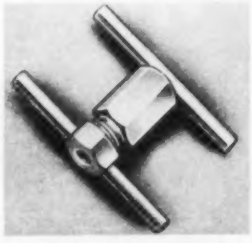
340 to 130,700 in-lb. Maximum operating angle is 90 deg. Joints are available solid or bored, with hub diameters from ½-in. to 4 in. and lengths from 4 to 21¼ in. **Lovejoy Flexible Coupling Co.**, 4800 W. Lake St., Chicago 44, Ill.

Circle 471 on page 19

Leak Test Fitting

is available in sizes from 3/16 to ½-in.

Sealastic fitting is designed for leak testing fabricated tubing on equipment such as refrigerator evaporators, cold plates, condensers and compressors. It also facilitates charging, flushing and evacuation. The unit is easy to tighten



and disconnect, and provides a pressure-tight leakproof joint. Construction employs a renewable synthetic rubber seal ring in both solid and ferruled assemblies. Fitting is cadmium-plated brass, and is available in sizes from 3/16 to ½-in. **Chicago Forging & Mfg. Co.**, 2000 Southport Ave., Chicago 14, Ill.

Circle 472 on page 19

Leaded Steel

has good machining characteristics

Hi-Qua-Led steel is produced in all steel grades in forged and rolled rings from 18 to 145 in. diameters and in ingots to 50,000 lb. Phys-

NOW—all the advantages of
Permanent Molding—plus Intricate Shell Coring *in*

EATON PERMANENT MOLD GRAY IRON CASTINGS

PERMANENT MOLD GRAY IRON CASTINGS meet critical quality requirements, including intricately cored sections, in a wide range of applications. These castings permit higher machining feeds and speeds, with substantially increased tool life. Characteristics of these castings include dense, non-porous, homogeneous structure, freedom from inclusions, excellent tensile strength, and the ability to take high surface finishes.

These qualities particularly recommend Eaton Permanent Mold Gray Iron Castings for such uses as high pressure control mechanisms, refrigeration and air conditioning parts, power steering and power braking components, household appliance parts, pump bodies, hydraulic cylinders, and countless other critical applications.

If you have applications where more than ordinary quality is required, our engineers will be happy to work with you.

EATON MANUFACTURING COMPANY
FOUNDRY DIVISION
VASSAR, MICHIGAN

Circle 594 on page 19

Wherever you want to protect something
. . . that's a place for A-L Stainless Steel

In a textile plant, like the applications pictured above, Allegheny Ludlum Stainless Steel protects against off-colors in the dyeing and finishing department because it cleans up easily and quickly from batch to batch, leaving no traces of the previous dyes. In yarn twisters and other equipment in the weaving department, A-L Stainless provides the hard, smooth surface and high abrasion-resistance that protects against snagging and binding.

Food, beverage, dairy, drug and chemical plants use A-L Stainless Steel to protect the purity of their products; hospitals, hotels and restaurants use it to protect appearance and sanitary standards; cars, trains and planes use it to protect strength and safety. And they all gain a host of bonus benefits from stainless steel, too: such as far less cleaning and maintenance expense, far longer life in service, and far greater economy in the long run.

No other metal can match stainless steel in these qualities. In addition, A-L Stainless is easy to fabricate and we produce it in every form or shape that you may require.

● Let us help you to profit by it. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

Write for your copy of "STAINLESS STEEL IN PRODUCT DESIGN"

40 pages of useful engineering and fabricating data, including practical examples showing where, when and how stainless steel improves design, adds benefits, helps sales.

ADDRESS DEPT. MD-83

For Stainless Steel in ALL Forms—call

Allegheny Ludlum

Warehouse stocks carried by all Ryerson Steel plants

AL STAINLESS STEEL

Circle 595 on page 19

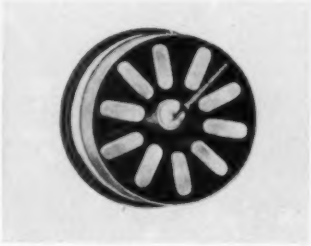
ical properties of the steel are unchanged by addition of lead; pattern of lead distribution is unaffected by the grade of steel. Machining characteristics are good. Tests show up to 71 per cent time savings in lathe operations and 50 per cent in gear tooth cutting as compared to carbon steel. Tool life is markedly increased and tests show an improvement in surface finish. **Alco Products Inc.**, Box 1065, Schenectady, N. Y.

Circle 473 on page 19

Miniature Crystal Oven

has temperature stability of ±0.25 C

Miniature crystal oven houses ten high-frequency holders, has a seated height of 1 in., and weighs 1.6 oz. Temperature stability is ±0.25 C at a constant ambient temperature, and temperature variation



after warmup is 2 C over ambient temperature range of −55 to 75 C. At −55 C, warmup period is 7 minutes. The unit is available in heater voltages from 6.3 to 115 v, ac or dc. Maximum power requirement is 25 w. The oven has a detachable cover, high temperature heater bonding tape, and bifilar low-inductance heater winding. **James Knights Co.**, Sandwich, Ill.

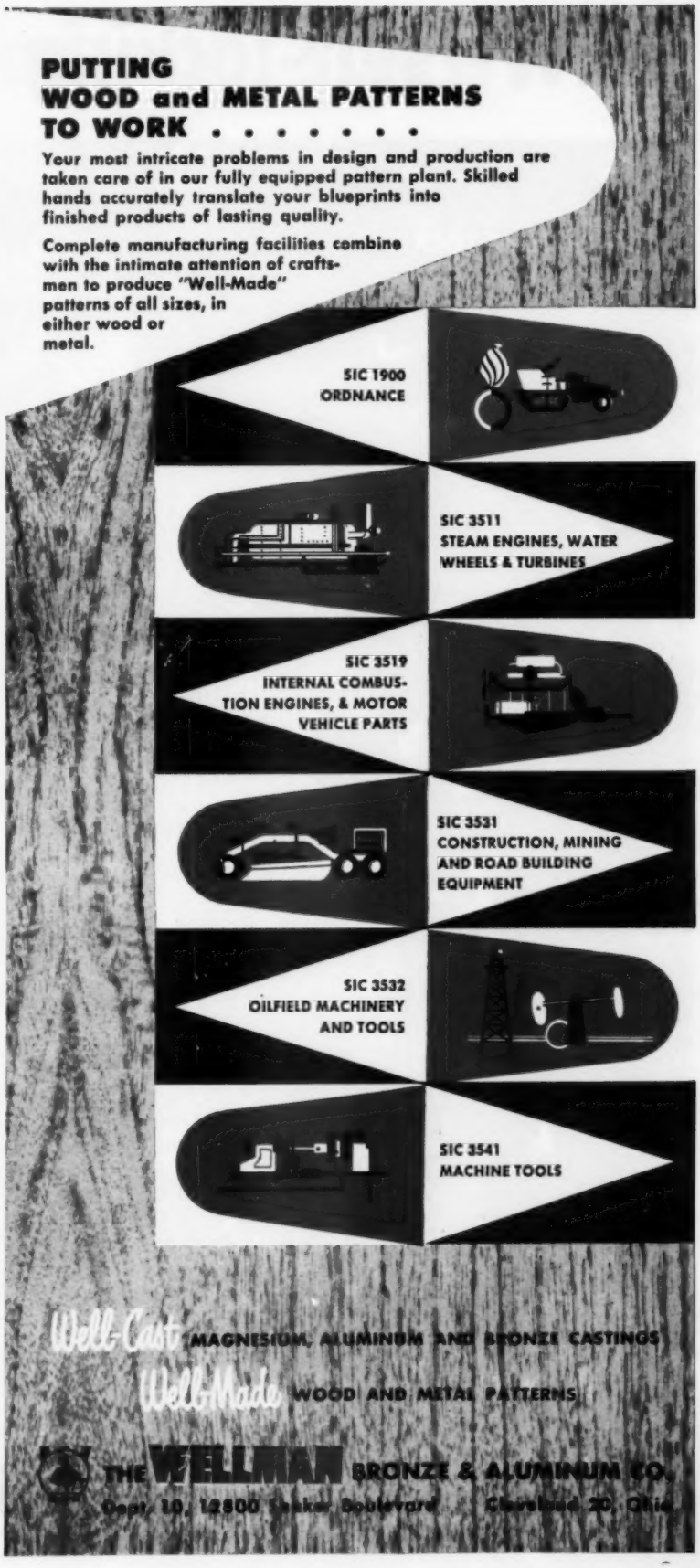
Circle 474 on page 19

Cable Turnbuckle

lightweight unit has new design

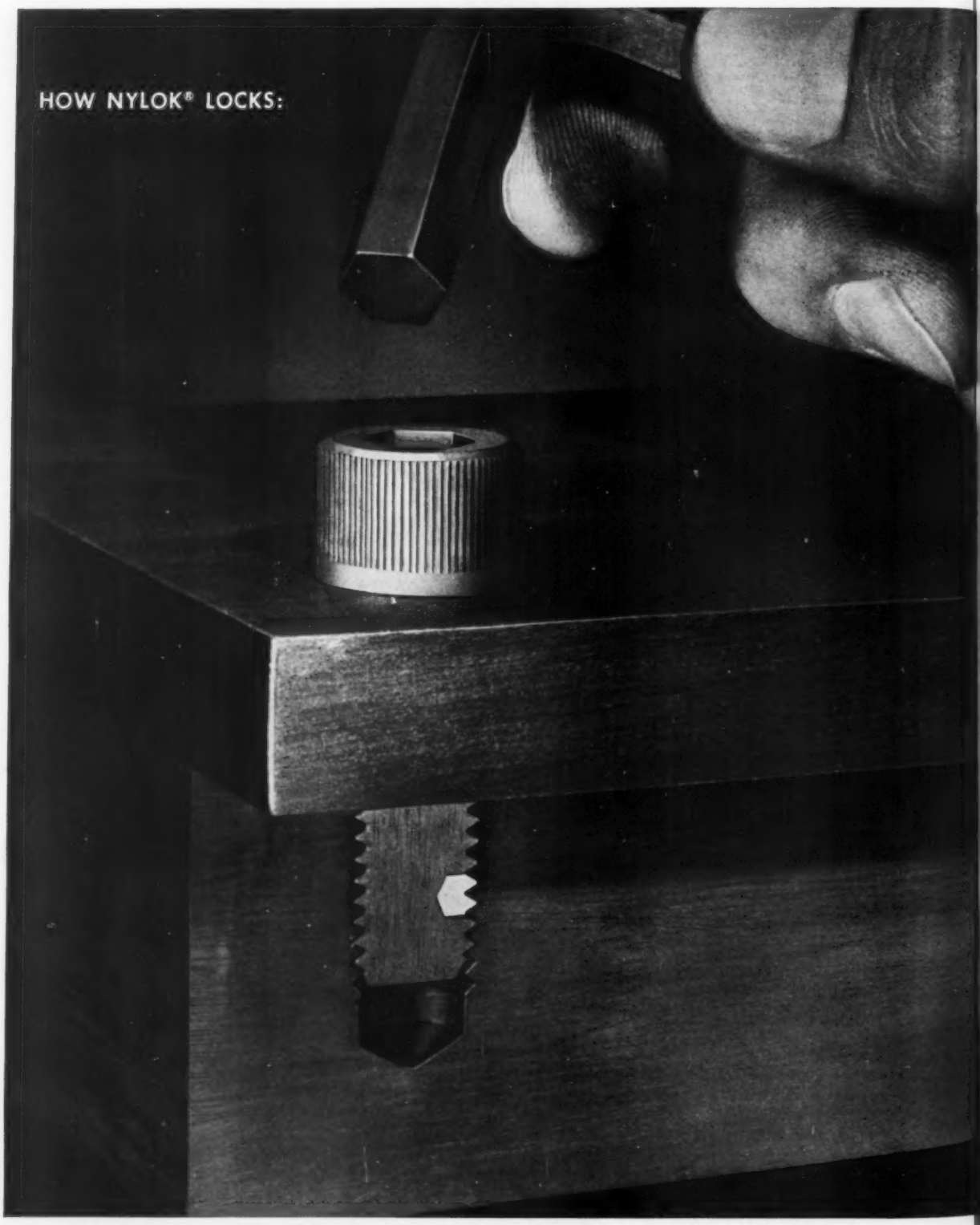
Lightweight turnbuckle of new design is about one-third as long and half the weight of conventional type. Constant length of unit facilitates installation. In use, balls are swaged on ends of cables. One cable end remains stationary and other seats on crosspiece of

(*Continued on Page* 168)


PUTTING
WOOD and METAL PATTERNS
TO WORK . . . . . .
Your most intricate problems in design and production are taken care of in our fully equipped pattern plant. Skilled hands accurately translate your blueprints into finished products of lasting quality.
Complete manufacturing facilities combine with the intimate attention of craftsmen to produce "Well-Made" patterns of all sizes, in either wood or metal.
SIC 1900
ORDNANCE
SIC 3511
STEAM ENGINES, WATER WHEELS & TURBINES
SIC 3519
INTERNAL COMBUSTION ENGINES, & MOTOR VEHICLE PARTS
SIC 3531
CONSTRUCTION, MINING AND ROAD BUILDING EQUIPMENT
SIC 3532
OILFIELD MACHINERY AND TOOLS
SIC 3541
MACHINE TOOLS
Well-Cast MAGNESIUM, ALUMINUM AND BRONZE CASTINGS
Well-Made WOOD AND METAL PATTERNS
THE WELLMAN BRONZE & ALUMINUM CO.
Dept. LD, 12800 Shaker Boulevard Cleveland 20, Ohio

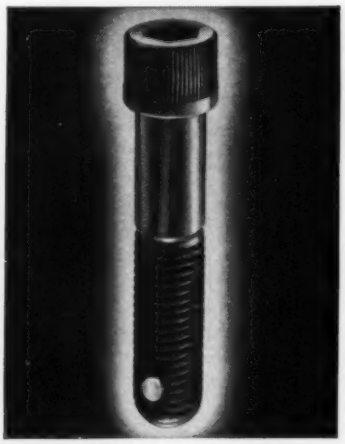
Circle 596 on page 19

NEW—self-locking UNBRAKO

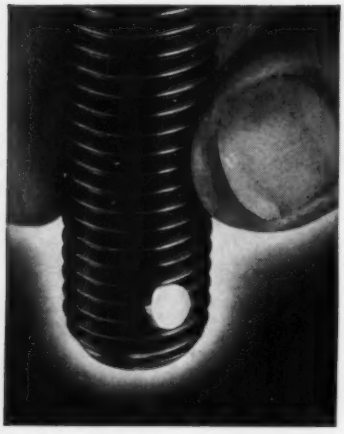


LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together and locks the screw securely.

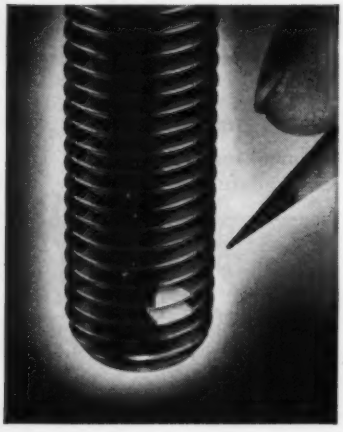
socket head cap screws



Self-locking UNBRAKO socket head cap screw.



BEFORE ASSEMBLY. The nylon pellet projects slightly. When assembled, threads will be impressed into it.



AFTER REMOVAL. "Plastic memory" of pellet has expanded impressed threads to greater diameter than screw threads. Screw can be used repeatedly. In use, "memory" keeps threads tightly locked.

They won't work loose. And they simplify design and save production time.

UNBRAKO socket head cap screws are now available embodying the Nylok* self-locking principle. Nylok provides the first truly practical solution to the problem of making cap screws self-locking.

An UNBRAKO cap screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not work loose.

You save production time when you make products with self-locking UNBRAKOs. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. And in many cases you will save weight and mass by using shorter screws in tapped holes instead of drilling through and using nuts and lockwashers.

Self-locking UNBRAKOs are reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, when screws are properly seated, the locking pellet also functions as a liquid seal.

A complete line of self-locking UNBRAKO socket screw products, in a wide range of standard sizes, materials and finishes, is available through your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

Circle 597 on page 19

XUM

STEARNS BRAKES

The motor makers' choice for positive stop-start

Stopping motors quickly is a key factor in cutting waste time—stepping up production. Here are a few important reasons why America's leading motor makers and design engineers specify Stearns magnetic disc brakes to do this profit-building job.

NEW DESIGNS — Now magnetic disc brakes to meet new NEMA frame standards in the 1/20 to 1/3 hp motor range; 1/6 to 2 hp motor range.

WIDE SIZE RANGE — for 1/20 to 100 hp motor, AC or DC. 6 lb in. to 7,500 lb ft torque range. Intermittent or continuous duty.

THREE HOUSING TYPES — Explosion-proof, dust-tight and watertight, standard. Vertical or horizontal, motor or floor mounting.

FAST STOP — Positive spring action on pressure plates.

QUICK RELEASE — Instantaneous magnetic pull — eliminates drag.

CUT COSTS,
sharpen quality control
WITH STEARNS MAGNETIC BRAKES AND CLUTCHES

STEARNS CLUTCHES

Matched-to-the-machine for smooth acceleration and release

When you design new installations, modernize or adapt existing machines, be sure of matched power transmission control with a Stearns magnetic clutch. Stearns not only builds a wide variety of standard clutches and clutch-brake combinations, but also designs special custom-built units tailored exactly to your specific installation.

WIDE TORQUE RANGE — .4 to 30,000 lb ft.

LOW INERTIA — Fast, smooth engagement and disengagement.

VARIED DESIGNS — Through shaft, split shaft, duplex for two speed drives, forward and reverse drives—other special applications.

WIDELY ADAPTABLE — DC or AC with rectifier. Automatic and remote control. Operates in conjunction with electronic circuits.

QUIET AND COOL RUNNING — Generous friction surface area and low unit pressure.

EASY WEAR ADJUSTMENT — Provides longer clutch life.

SIMPLE INSTALLATION—no toggles, yokes, shifters.

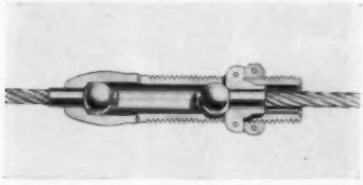
For full details consult your 1956 Sweet's Product Design file or write for Bulletin 226-E. 1097

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN
formerly STEARNS MAGNETIC INC.

New Parts

(*Continued from Page* 165)

turnbuckle which is adjustable by means of nut on exterior of sleeve. Tightening nut moves crosspiece,



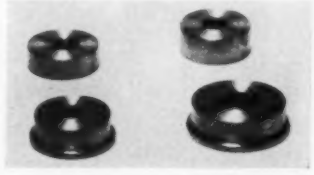
placing desired tension on cable. Twisting of the cable does not occur. Unit is permanently lubricated with baked-on graphite. Made of aluminum and steel, unit is intended for use with aircraft cable in sizes up to 7/32-in. **Pheoll Mfg. Co.**, Aviation Div., Los Angeles, Calif.

Circle 475 on page 19

Bronze Bearings

have bore sizes of ⅛-in. through ¼-in.

Oil-less bronze bearings are interchangeable with 1 in. series plain or flanged ball bearing. Bearings

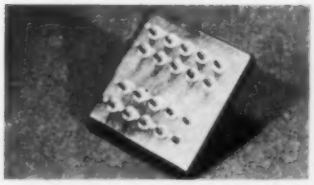


are manufactured to close tolerances and are available from stock in bore sizes of ⅛, 3/16, and ¼-in. **PIC Design Corp.**, P. O. Box C, East Rockaway, L. I., N. Y.

Circle 476 on page 19

Teflon Terminals

in miniature and subminiature sizes

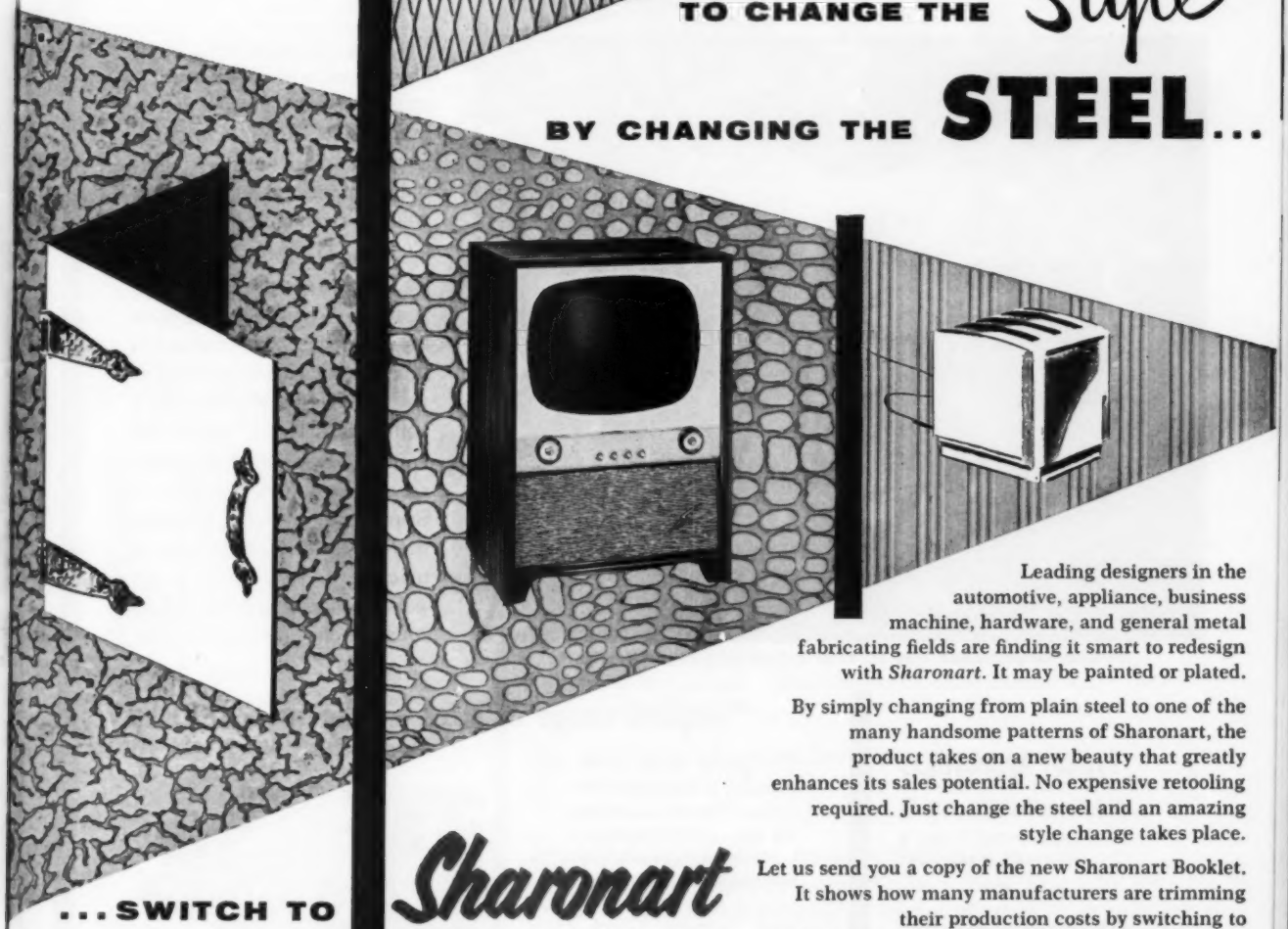


Teflon press-fit terminals have dielectric strength ranging from 1000 to 2000 v per mil thickness. Offering close terminal spacing for use in limited spaces, such as in

it's smart

TO CHANGE THE Style

BY CHANGING THE **STEEL**...



...SWITCH TO **Sharonart**

Leading designers in the automotive, appliance, business machine, hardware, and general metal fabricating fields are finding it smart to redesign with *Sharonart*. It may be painted or plated.

By simply changing from plain steel to one of the many handsome patterns of Sharonart, the product takes on a new beauty that greatly enhances its sales potential. No expensive retooling required. Just change the steel and an amazing style change takes place.

Let us send you a copy of the new Sharonart Booklet. It shows how many manufacturers are trimming their production costs by switching to these attractive surface-rolled patterns in steel.

SHARON STEEL CORPORATION
Sharon, Pennsylvania

SHARONSTEEL

DISTRICT SALES OFFICES

CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, MONTREAL, QUE., TORONTO, ONT.

SHARON STEEL CORPORATION
Sharon, Pennsylvania MD-11-15-56

Please send "SHARONART Surface-Rolled Patterns in Steel" Brochure.

Name.....

Position.....

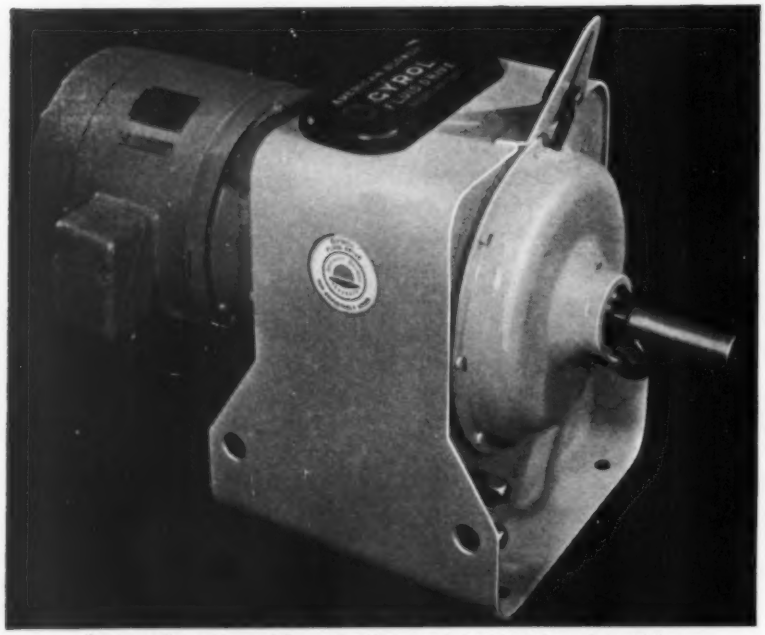
Company.....

City.....Zone.....State.....

Circle 599 on page 19

XUM

Why you should include Gýrol® Fluid Drives in your plans for automation



Compact, flange-mounted Type VS, Class 2 Gýrol Fluid Drive — 1 to 25 hp.

For one thing, Gýrol Fluid Drives provide adjustable, *stepless* speed control of driven machinery, using *standard*, constant-speed motors — without complicated electric circuits or starting devices.

Adaptable to remote, manual, or automatic speed control, Gýrol Fluid Drives are compact, self-contained units — requiring only the conventional flexible-coupling connections to the motor and load. They provide complete shock absorption, are easy to install in a variety of arrangements of driving to driven machinery. Why not call our nearest branch for full details today?

Typical Applications

PUMPS, AGITATORS, MIXERS

CONVEYORS, CABLE & ROPE MACHINERY

FANS AND BLOWERS

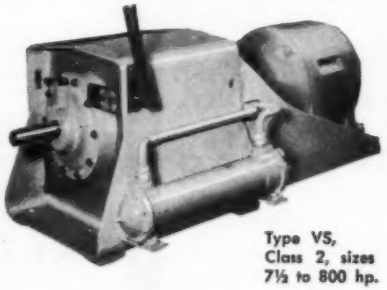
CENTRIFUGAL COMPRESSORS

PAPER AND PRINTING MACHINERY

TEXTILE MACHINERY

Complete range of sizes — 1 hp to 12,000 hp

The Gýrol Fluid Drive line includes a complete range of sizes, from 1 to 12,000 hp. All save power through lower horsepower requirements. A minimum number of wear points cuts maintenance. And, because Gýrol Fluid Drives bring about reduced speeds and pressures, driven equipment lasts longer.



Type VS, Class 2, sizes 7½ to 800 hp.

American Blower products serve industry

- Air Conditioning, Heating, Ventilating Equipment
- Mechanical Draft Equipment
- Industrial Fans and Blowers
- Centrifugal Compressors
- Gýrol Fluid Drives
- Dust Collectors
- Refrigerating Machines

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of American-Standard

AMERICAN **BLOWER**

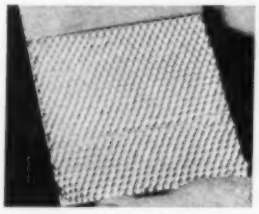
canned transformers, precision potentiometers and coil assemblies, terminals may be mounted only ¼-in. between centers. Feed-thru model has turret lugs for inside and outside wrap-around and soldered connections. Terminals are available in both stand-off and feed-thru designs, in miniature and subminiature sizes and are readily installed by press-fitting into prepared holes. **Sealectro Corp.**, 610 Fayette Ave., Mamaroneck, N. Y.

Circle 477 on page 19

Liquid Adhesive

for metal-to-metal structural bonding

Modified phenolic liquid adhesive produces bond shear strengths of 5300 psi at room temperature, exceeding requirements of military specifications. Designated as EC-1471, adhesive has good peel



strength and maintains its high strength properties over temperature range of −65 to +180 F. Shear strength of 5300 psi is obtained with 45 minute cure at 350 F. Primary application is for bonding metal facings to honeycomb core material, but adhesive may be used for general metal-to-metal bonding. **Minnesota Mining and Mfg. Co.**, Adhesives and Coatings Div., 423 Piquette Ave., Detroit 2, Mich.

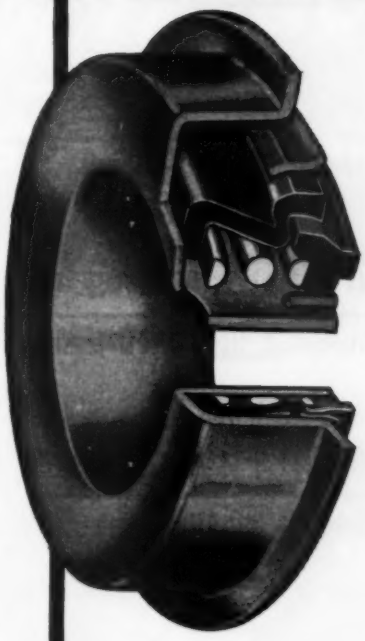
Circle 478 on page 19

Relay

high-torque unit has high sensitivity

Relay for operation under environmental conditions of shock and vibration and ambient temperatures of −55 to 150 F has high locking torque. Sensitivities from 0.2-mu amp to 10 amp, or 0.1-mu v to 500 v can be furnished. Alternating current relays have built-in silicon or germanium diodes or copper

YOU ASSURE...



✓ Greater Economy
✓ Better Performance
WITH
JOHN CRANE
SELF-ALIGNING
TYPE 11-A
Rotary Shaft
SEALS

BECAUSE:

1. **You save on production time.** The Type 11-A Seal is a low cost, compact, factory assembled unit. Its "pressed-in" cartridge-type construction makes for quick installation as equipment rolls by.
2. **One seal size fits several shaft diameters.** Retainer is so constructed that it does not contact the shaft, eliminating the need to "switch" seals when shaft specifications vary slightly.
3. **Damaging stresses are eliminated.** Since the entire unit remains stationary, the seal readily lends itself to applications involving high speed and vibration.
4. **Safeguarded against corrosion.** Metal spring utilized to maintain constant contact of sealing faces is fully enclosed in synthetic rubber bellows. This eliminates the need for costly corrosion-resistant spring materials.

"John Crane" Type 11-A Seals are recommended for temperatures to 212°F., pressures to 20 psi. Available in four stock sizes from ⅛" to ¾".

Contact "John Crane" engineers on your requirements today. Request illustrated catalog on complete line of seals for all services.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd. Hamilton, Ont.*

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PRIORITY

Circle 601 on page 19

XUM

WHEELOCK, LOVEJOY & COMPANY, INC.
1250 Marquette Street, Cleveland Ohio

WHEELOCK, LOVEJOY & COMPANY, INC.
1855 So. Kilbourn Avenue, Chicago Illinois

WHEELOCK, LOVEJOY & COMPANY, INC.
265 Pennsylvania Avenue, Hillside New Jersey

WHEELOCK, LOVEJOY & COMPANY, INC.
12989 Greeley Avenue, Detroit Michigan

7 WAREHOUSES AT YOUR SERVICE

You'll get quick action on your order for alloy steel bars, billets or forgings . . . no matter what size, shape or heat treatment you require . . . when you call any one of our seven warehouses.

All seven are conveniently located in principal industrial areas. Each is staffed by expert metallurgists, and is well-stocked to give you speedy service.

Fill your current needs by ordering our own HY-TEN steels, the "standard steels of tomorrow", or standard AISI or SAE grades.

Or write today to our Cambridge office for your *free* Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

In Canada: Sanderson - Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.
144 Milton Street, Buffalo New York

WHEELOCK, LOVEJOY & COMPANY, INC.
4524 W. Mitchell Avenue, Cincinnati Ohio

HOME OFFICE:
WHEELOCK, LOVEJOY & COMPANY, INC.
133 Sidney Street, Cambridge 39 Massachusetts

New Parts

oxide rectifiers, depending upon performance requirements. Trip point accuracy varies from 1 to 25 per cent. Single-contact high limit (one pair close on increase) or single-contact low-limit models can be supplied as well as double-con-

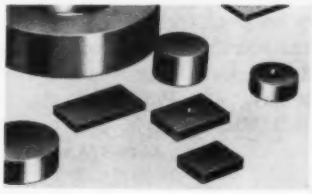
tact models (both high and low). Contact ratings are from 5 to 125 mu amp dc. Relay has moving coil armature which rotates in flux gap of an Alnico magnet. Contacts are solid iridium-platinum alloy. Locking coil develops additional torque to drive contacts together under pressure. Reset can be manual or automatic. **Assembly Products, Inc.**, Desert Hot Springs, Calif.

Circle 479 on page 19

Ceramic Magnet Material

has high peak energy product

Ceramic permanent magnet material has coercive force (Hc) of 1700 oersteds, residual induction (Br) of 2100 gauss, and peak energy product (BH max) of 0.8 x 10^6, permitting smaller magnets



for equal performance as other materials, or increased performance with equal volume. Material is a non-conductor and is hard, brittle, and much lighter in weight than metallic alloys used as magnetic material. Ceramic material has high resistivity, low specific gravity, high potential energy and low incremental permeability. **Indiana Steel Products Co.**, 700 Valparaiso St., Valparaiso, Ind.

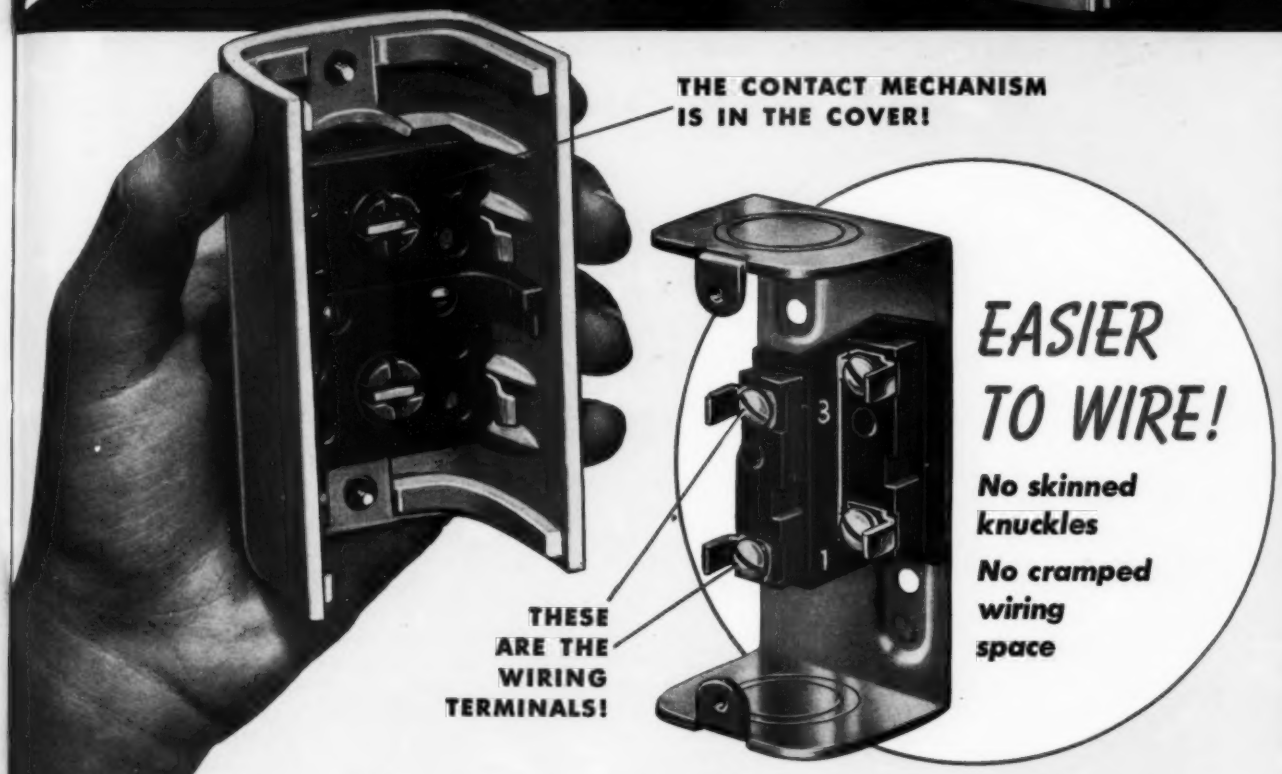
Circle 480 on page 19

Circle 602 on page 19

Circle 603 on page 19→

Brand New Idea

in STANDARD-DUTY STATIONS



EASIER TO WIRE!

No skinned knuckles

No cramped wiring space

Here's an entirely new idea in push button stations—a wrap-around cover—with the contact mechanism part of the cover. Removing the cover exposes the terminals for instant and easy wiring. Strong, spring type, silver plated contacts connect the push button assembly in the cover with the terminals in the base.

Matching ribs in the cover and notches in the terminal blocks assure that the wiring connections are always correctly made. A bakelite shield protects the contact mechanism and prevents careless wiring from interfering with the contact operation. Concentric knockouts are provided in both top and bottom of the heavy metal base.

You will want to know about this new standard-duty station because—it is good looking—it takes less time to install—it was designed for the convenience of the installation engineer.

Let us show you a sample of this "brand new idea" in standard-duty stations!

A-B Quality

ALLEN-BRADLEY

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ontario

Bulletin 800 standard-duty push button stations can be supplied with one, two, or three buttons, or as a selector switch. Also available with pilot light. Furnished only in NEMA Type 1 enclosures.

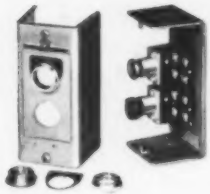
9-56-MR

XUM

Also... *NEW* **HEAVY-DUTY PUSH BUTTONS**

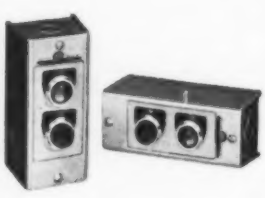
BULLETIN 800

NEW FLEXIBILITY!



You can assemble any special heavy-duty station from a small stock of standard push button, selector switch, and pilot light components. There is no need to wait for long delivery of your special stations.

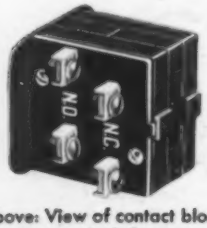
Stations can be arranged for either vertical or horizontal mounting. Name plates can be rotated to any position, replaced with any standard marking, or removed entirely.



NEW ENCLOSURES!

Each button, selector switch, or pilot light is a self-contained unit which can be mounted in attractive new enclosures. Standard enclosures accommodate up to eight units, but enclosures can be furnished for larger numbers.

NEW CONTACT BLOCK!



Above: View of contact block, showing terminals for normally open and normally closed contacts. Right: Contact block, with cover removed, showing stationary silver alloy contacts and pushrod carrying the moving contacts.

Bulletin 800 heavy-duty push buttons have the same molded contact blocks that have proved so dependable in Bulletin 800T oiltight push buttons, although they are not themselves oiltight. And all of them are equipped with double break, silver alloy contacts.

NEW OPERATORS!

Operators, which mount on the contact block, are available in many types, and push buttons come in various colors.

Type AK2B flush head START button

Type DK6A mushroom head button

Type PK16 pilot light with transformer

Type EK11B cylinder lock unit

9-56-MR

A-B Quality

ALLEN-BRADLEY

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. In Canada—Allen-Bradley Canada Ltd., Galt, Ontario

XUM

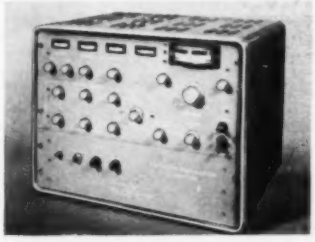
ENGINEERING DEPARTMENT

EQUIPMENT

Phasemeter

has 0.1 per cent accuracy

Phasemeter permits direct reading of phase differences between sinusoidal voltages from 0 to 360 deg, with provision for sense indication to avoid 180 deg ambiguity. Phase angle is measured to absolute accuracy of 0.1-deg with incremental accuracy of 0.01-deg at all frequencies from 30 to 20,000 cps. Phase angles are read directly



from calibrated two-degree step control in combination with a 4-in. vernier indicator having a linear range of ±1.0 deg. Input impedance for each channel is 10 megohms shunted by 25 micromicrofarads. Each input channel handles signals from 0.5 to 5.0 v rms. Instrument also provides output for recording purposes. **W. L. Maxson Corp.,** Maxson Instruments Div., 47-37 Austell Place, Long Island City 1, N. Y.

Circle 481 on page 19

Electronic Counter

gives direct reading of variable in desired units

Electronic counter gives precise measurements of speed, rpm, pressure, thickness, and other quantities directly in desired units. Unit has variable gate time which functions as multiplier of transducer input to provide direct readings. Instrument has front-panel plug-in board that automatically sets any predetermined conversion multiplier. Gate time is manually ad-

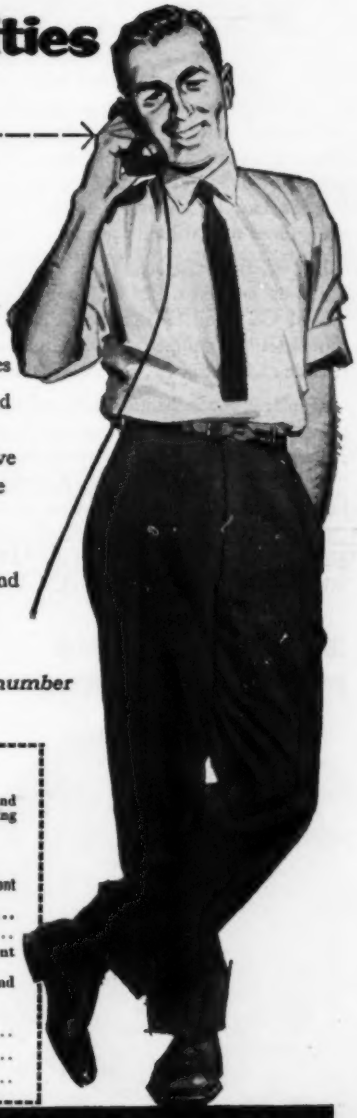
(Continued on Page 178)

Designers

OPERATION TELEPHONE

may introduce you to

unusual advancement opportunities



Across the nation, we have talked by phone with men who have expressed interest in our design work. Easily, quickly they have been able to get the important facts on our attractive career opportunities

If *you* are restless — perhaps in a deadend job — mail the coupon *immediately*. Chances are we will call you shortly — give you an opportunity to verbally investigate what we have to offer.

Ability shows up fast in our design work. Some of our top men, with top earnings and responsibility, are comparatively young. It could happen to you.

Be sure to give us your home telephone number

Mr. E. M. Peterson, Dept. 4, Design Employment
Pratt & Whitney Aircraft, East Hartford, Conn.

I would like to learn more about your openings for product and component designers. My experience has been in the following fields:

☐ Nuclear Design ☐ Aerodynamics ☐ Bearings
☐ Compressors ☐ Hydraulics ☐ Piping
☐ Turbines ☐ Gears ☐ Controls
☐ Structures ☐ Valves ☐ Test Equipment
☐ Afterburners and Related Equipment ☐ Heat Exchangers and Combustion Problems ☐ Test Rigs

Total years Mechanical Design experience .....
You can reach me at ..... Most convenient (home telephone)
hours for receiving calls are between .....and .....

NAME .....
HOME ADDRESS .....
CITY .....STATE .....

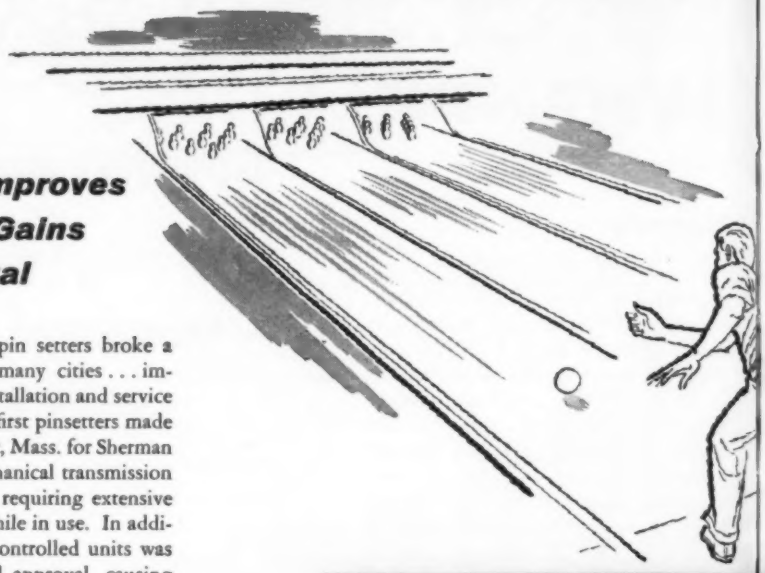
PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION, EAST HARTFORD 8, CONNECTICUT

World's foremost designer and builder of aircraft engines

XUM

WARNER ELECTRIC CLUTCHES EASILY CONTROL COMPLEX MOTIONS OF AUTOMATIC PINSETTER

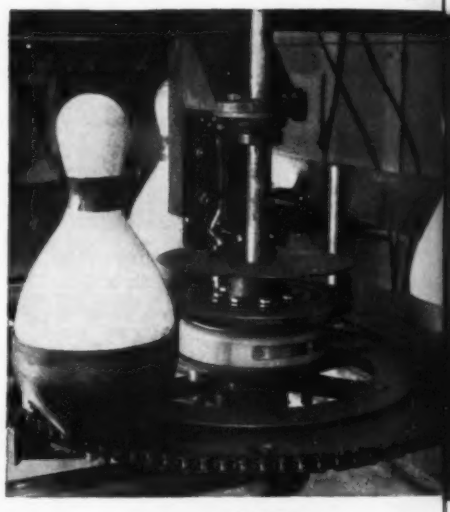


Electric Motion Control Improves Automatic Performance, Gains Class II Electrical Approval

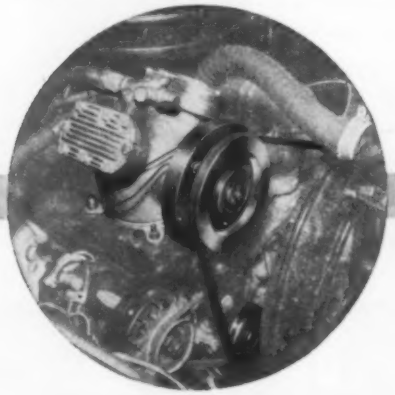
Here's how a manufacturer of automatic duckpin setters broke a bottleneck preventing use of the machine in many cities . . . improved machine performance . . . and reduced installation and service costs with Warner Electric Motion Control. The first pinsetters made by Crompton & Knowles Loom Works, Worcester, Mass. for Sherman Enterprises, Worcester, were equipped with mechanical transmission and braking controls . . . complex in operation, requiring extensive adjustment at installation and frequent service while in use. In addition, the voltage demand of the mechanically controlled units was so high that Underwriters' Laboratories refused approval, causing many cities to withhold operating licenses.

Use of Warner Electric Clutches was the solution to Crompton & Knowles' problems. The low operating voltage of the Warner system gained UL Class II Signaling Circuit approval . . . installation became greatly simplified . . . the timing sequence and operation more reliable and precise . . . and field service greatly reduced.

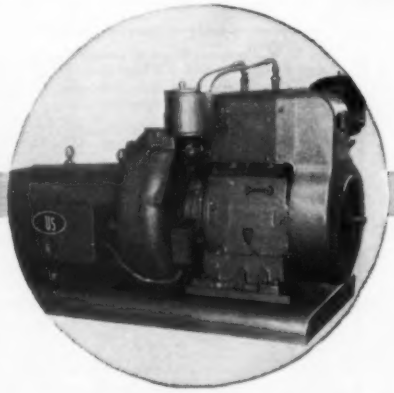
Warner Electric Motion Control systems offer you pushbutton, centralized control integrated with your machine's electrical circuit . . . expand the uses of all types of automatic control devices . . . give you the exact operating characteristics needed to do every job better, at lower over-all cost. You get faster, more precise starts and stops . . . and you benefit from simplified design and installation. Use the coupon on the next page to obtain the complete story on Warner Electric Motion Control.



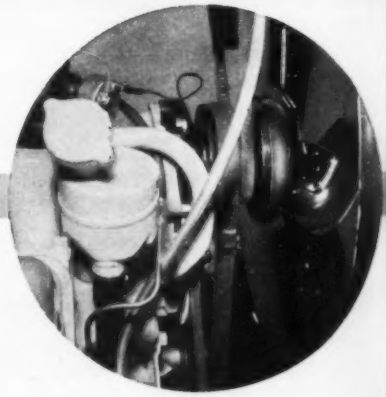
EASILY SOLVES POWER PROBLEMS LIKE THESE



Automobile Air Conditioning—Automatic control provided by Warner Clutch has stationary magnetic field mounted on compressor seal plate and rotor keyed to compressor shaft with armature-pulley mounted on rotor hub. Pulley driven by engine crankshaft. Clutch field is energized by thermal control coupling armature and pulley, driving compressor. Control releases clutch when proper temperature is reached.

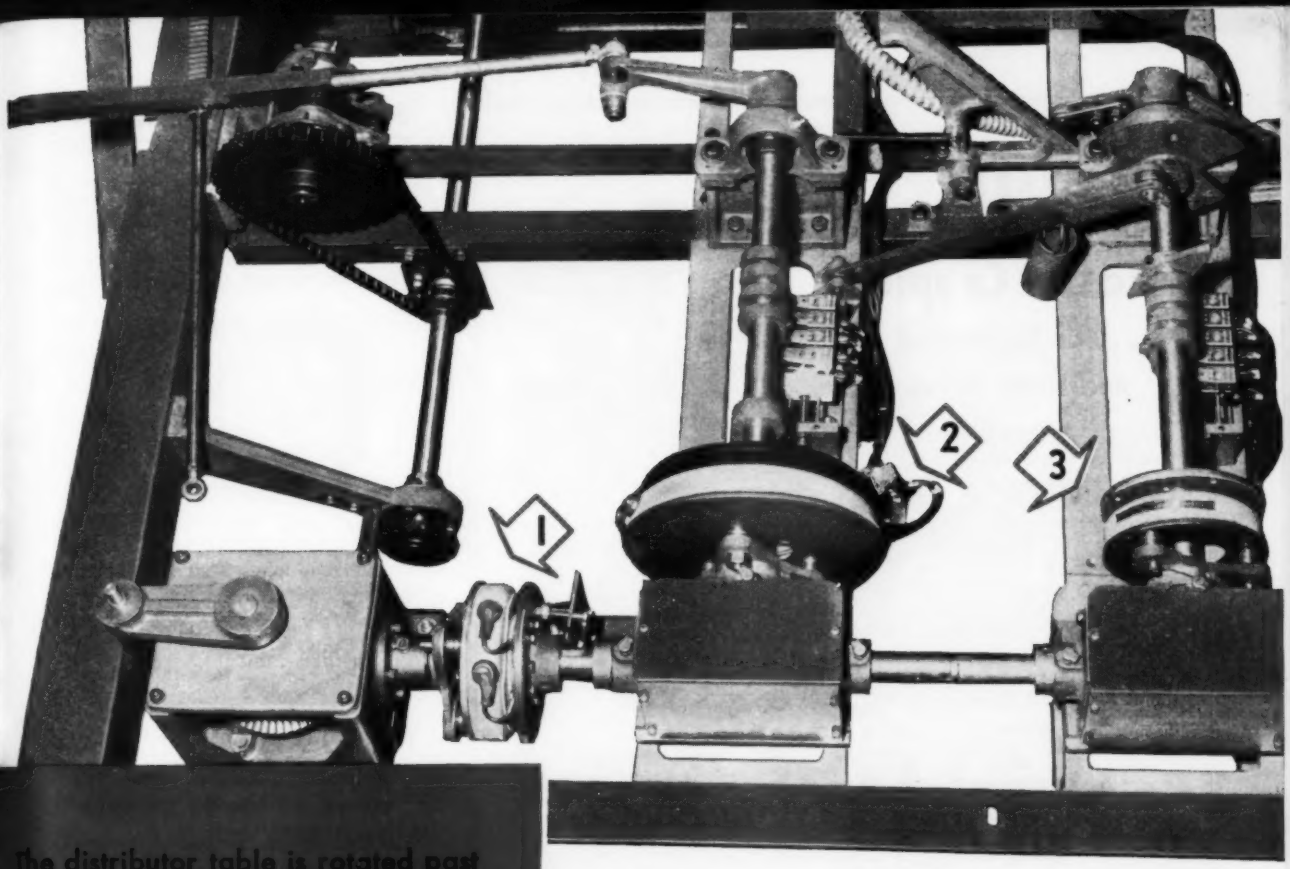


Stand-By Power Plant—Electric Clutch is mounted on shaft between heavy flywheel of continuously running electric motor alternator and gas engine. Power failure or drop disengages motor from prime supply and energizes field, engaging flywheel with engine. Inertia of wheel starts engine, preventing power interruption or variance. Sequence occurs instantly with only 4 or 5 volt lag for a few seconds on 110 volt lines.



Heavy Truck Fan Clutch—Clutch armature and fan are mounted on stationary shaft adjacent to rotor and pulley assembly. Integral rotor and pulley turn continuously. Field is mounted on water pump. Thermal switch in water cooling system energizes field, attracting armature and driving fan. Intermittent operation makes more horsepower available to the vehicle and provides faster warmups in cold weather.

XUM

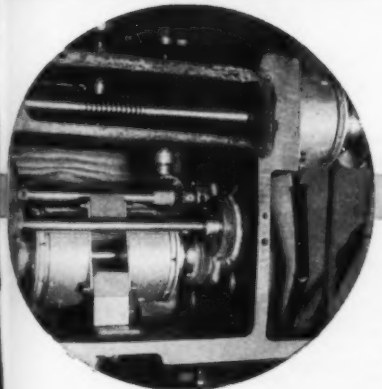


The distributor table is rotated past a chain pin conveyor until all ten cups are filled—pins are then held until needed by pin table. Warner Electric Clutch provides quick, precise control of full sequence.

1 When bowler steps on switch at the head of the alley, this Warner Clutch and timer arrangement activates the sweep arm to clear "dead" pins from the alley.

2 The pin table which places the pins in position or lifts them while sweep arm cleans alley is precisely controlled by this Warner Electric Clutch arrangement.

3 Pins lifted from the alley pit are received by the distributor table and delivered as required to the pin table. This Warner Electric Clutch actuates the delivery table sequence.



Bobbin Resistor Winder—Unusual use of Warner Brake on wire guide carriage. Brake is energized continuously to hold worm gear stationary as it traverses machine's screw. When brake is de-energized at end of winding operation, worm gear is released, returning carriage to start. Second brake on spindle stops winding at exact preset turn. Two Warner Clutches control winding and reversing traverse.

Circle 604 on page 19

WARNER

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

Please send me copy of your new Condensed Catalog No. 6212.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

XUM

NEW! low-price Fast's Coupling

. . . for light and medium drives!

It's the new MODEL B—lighter, smaller, with all the famous Fast's features—yet priced at a new *low!* The new MODEL B is designed for light-to-medium drive units such as fans, blowers and pumps —where cost is important. Now these products can afford the rugged construction and trouble-free performance of genuine Fast's Couplings.

All steel, dust and moisture proof with metal seal, the new MODEL B is available for shaft sizes up to 2⅝". Sold with Koppers *free* engineering service!

Find out how the new Fast's MODEL B can solve your coupling problem. Write, wire or phone: KOPPERS COMPANY, INC., Fast's Coupling Dept., 3511 Scott St., Baltimore 3, Maryland.

KOPPERS

THE ORIGINAL **FAST'S Couplings**

Engineered Products Sold with Service

Circle 605 on page 19

Design Guide to

"Adjustable-Speed Drives"

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

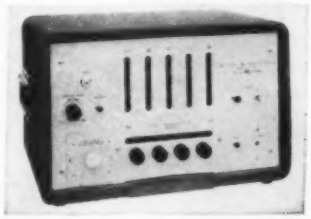
$2.00 per copy

MACHINE DESIGN READER SERVICE
Penton Building Cleveland 13, Ohio

Engineering Equipment

(*Continued from Page* 175)

justable from 0.0001 to 0.9999 second in 0.0001 second increments. Provision is made for a second input to permit measuring ratios



of two independent variables and direct readings of such quantities as engine revolutions per gallon. **Dynac Inc.**, 395 Page Mill Rd., Palo Alto, Calif.

Circle 482 on page 19

Phase Generator

measures unknown voltage phases and transfer functions

Laboratory phase generator gives constant output voltage whose time phase varies linearly with dial rotation. Phase-shift accuracy of 1 deg of dial reading is standard.

but 5 min. accuracy can be provided. Unit is for measuring transfer functions, unknown voltage phases and to provide reference phase for phase-sensitive detector circuits. Output voltage is 10 v, 400 cps, input is 115 v. **Theta Instrument Corp.**, 204 Market St., East Paterson, N. J.

Circle 483 on page 19

Thermostat

has range of 200 to 500 F

Thermostats available in wide range of types are simple in design and are ruggedly construct-

TORRINGTON PRESENTS:

An important new line of complete blower units for central air conditioning, heating and ventilating, in a wide range of sizes, full and three-quarter widths, and incorporating the following exclusive Torrington features:

1. An exceptional new Center-Lock airotor introducing an entirely new principle of blower wheel construction in which (see insert) the center disc is dovetailed under pressure into the encircling blades. As a result of this design feature, the interlocking joint *tightens* under centrifugal force, eliminating blade rattle and angle warp at high speeds.

2. A Multi-Position blower housing, easily adaptable to left or right, up or down flow requirements, of the finest welded steel construction and special finish.

3. Availability in either belt-driven or direct drive assemblies.

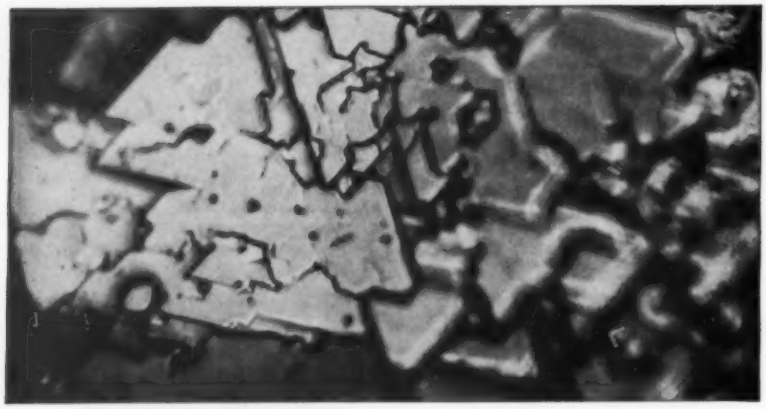
4. Unit flexibility, providing feet, motor mounting assembly to meet your individual mounting requirements.

This new product line is a major development backed by all the standards of engineering quality consistent with Torrington leadership in the air impeller industry. Your inquiries are invited.

THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

Circle 606 on page 19

XUM

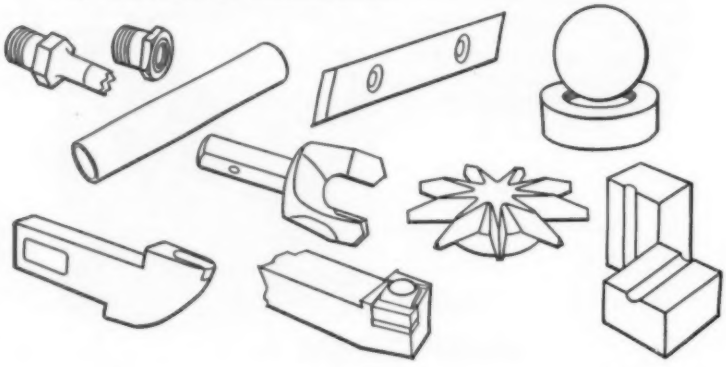


$WTiC_2$ Crystal (4000X). Photomicrograph of Kennametal tungsten-titanium crystal (4000X). This unique material is an important ingredient of Kennametal, and provides a combination of desirable characteristics in the steel-cutting and gall-resistant grades of Kennametal.

Where you can use KENNAMETAL* or KENTANIUM*

Kennametal was the first hard carbide to cut steel successfully. Since the original composition was invented, many additional distinctive grades have been developed. Each offers a wealth of possibilities to design engineers who are searching for a metal that has unusual strength and high hardness, or exceptionally high resistance to abrasion, deflection, deformation and impact.

A companion material, Kentanium, retains its high strength and exceptional resistance to oxidation and abrasion at temperatures 1800°F and higher. It is one-third lighter than steel and much lighter than other hard carbides. It possesses extremely high resistance to thermal shock.



With a combination of many desirable properties, Kennametal and Kentanium are providing unusual performance in diverse applications. Many of these applications and the properties required for each are discussed in our Booklet No. B-111. Perhaps it will give you the information you need to get your idea off the drawing board into production. Write for a copy. Address: Dept. SA, KENNAMETAL INC., Latrobe, Pa.

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Engineering Equipment

ed for long, dependable service life, accurate calibration, quick action and consistent, low differential operation. Thermostats have ratings of 25 amp, 120-240 v ac. Temperature range is 200 to

500 F, with other ranges available. Models include two and three position units and single dial units, both with or without automatic preheat operation. Applications are for use on range ovens, air conditioning and heating units, laboratory equipment, and industrial products, such as platens, steam tables, oil baths, and grease kettles. **Hart Mfg. Co.,** 101 Bartholomew Ave., Hartford, Conn.

Circle 484 on page 19

Variable Transformer

ac unit has output range of 0-132 v

Cased variable auto-transformer has range of output from 0 to 132 v ac from 120 v ac input. Maximum load rating is 165 va. Trans-

former is toroidally wound type. Unit has easily read dial, push-button switch, pilot light, fuse, cord, plug, and receptacle. Case size is 3⅞ x 3⅞ x 3½ in. Ventilated case is finished in baked wrinkle-enamel. Applications are for laboratory use, equipment requiring variable motor speed control, mixers, experimental work, and light control. **Standard Electrical Products Co.,** 2240 E. Third St., Dayton, O.

Circle 485 on page 19

THE ENGINEER'S

Library

Recent Books

International Dictionary of Physics and Electronics. 1004 *pages,* 7½ *by* 10 *in., clothbound; published by D. Van Nostrand Co. Inc.,* 120 *Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, $20.00 *postpaid.*

This new dictionary contains over 12,000 definitions of laws, relationships, equations, and basic principles and concepts, as well as the most widely used instruments, apparatus and their components. Major subject divisions include such fields as units and dimensions, general principles, mechanics, the gaseous state, the liquid state, the solid state, heat and thermodynamics, acoustics, optics, electricity, electronics, meteorology, atomic and nuclear physics, mathematical physics, quantum mechanics, and relativity. All definitions which have been established or recommended by responsible groups are included. The units and systems of units are treated both by definition and by a discussion at the beginning of the book.

Association Publications

ASTM Proceedings, 1955. 1226 *pages,* 6 *by* 9 *in., clothbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.;* $12.00 per copy.

These proceedings of the society for 1955 include many technical reports and papers together with the resultant discussions. There are 70 reports and 34 papers and their discussions and notes, covering a wide rage of subjects including materials, finishes, chemical analysis, and testing methods.

Bibliographic Survey of Corrosion 1952-1953. 382 *pages,* 8½ *by* 11 *in., clothbound; published by and available from National Association of Corrosion Engineers,* 1061 *M & M*

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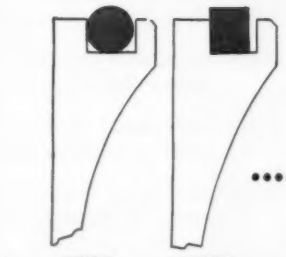

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The Engineer's Library

Bldg., Houston 2, Tex.; $10.00 *per copy to members,* $12.50 *to non-members.*

Summaries of 3344 corrosion and corrosion prevention articles, books, and brochures published during 1952 and 1953 are compiled in this volume. Material was selected from bulletins published by more than thirty abstracting agencies representing international literature coverage. Abstracts are divided into eight main groups: general, testing, characteristic corrosion phenomena, corrosive environments, preventive measures, materials of construction, equipment and industries.

Design Manual, Porcelain Enamel in Architecture, Part 1, Veneer-Type Construction. 22 *pages,* 8½ *by* 11 *in., paperbound, side stapled; published by and available free from Porcelain Enamel Institute Inc.,* 1145 19*th St. N.W., Washington* 6, *D. C.*

This booklet presents properties and applications of porcelain enamel, along with technical information, drawings, and illustrations of typical installations. Included is information relative to the comparatively new application of porcelain enamel on aluminum.

Manufacturers' Publications

Why D-C? 32 *pages,* 8½ *by* 11 *in., paperbound, published by and available free from General Electric Co., Direct Current Motor and Generator Dept.,* 3001 *E. Lake Rd., Erie* 1, *Pa.*

Written in layman's language, this booklet presents the case for direct-current electricity: what it is, how it is produced, and what its applications are. Applications discussed include tension control, feedback control of multi-motor drives, acceleration and deceleration control and frequent starts, stops and reversing.

Government Publications

The Experimental Measurement of Thermal Conductivities, Specific Heats, and Densities of Metallic, Transparent, and Protective Materials. 8½ *by* 11 *in., paperbound; prepared for Wright Air Development Center, U. S. Air Force; available from Office of Technical Services,*

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U. S. Dept. of Commerce, Washington 25, D. C.; in three sections:

PB 121289—136 pages; $3.50 per copy.
PB 121285— 39 pages; $1.00 per copy.
PB 121290— 78 pages; $2.00 per copy.

This three-part report gives the results of investigations of the thermal characteristics of possible exterior surface materials for supersonic aircraft and missiles.

Collection of Papers Presented at the Colloquium in Statistical Design of Laboratory Experiments. *Prepared by U. S. Naval Ordnance Laboratory, White Oak, Md.; 98 pages; 8½ by 10½ in., paperbound, side-stapled; copies available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $2.75 per copy.*

This series of lectures presents viewpoints which are useful to the engineer or scientist concerned with designing experiments and evaluating the significance of the data.

Wright Air Development Center Technical Reports. *Each publication is 8½ by 10½ in., paperbound, side-stapled; copies available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.*

The following Technical Reports are available:

PB 111648. A Review of the Air Force Materials Research and Development Program. 119 *pages,* $3.50 *per copy.*

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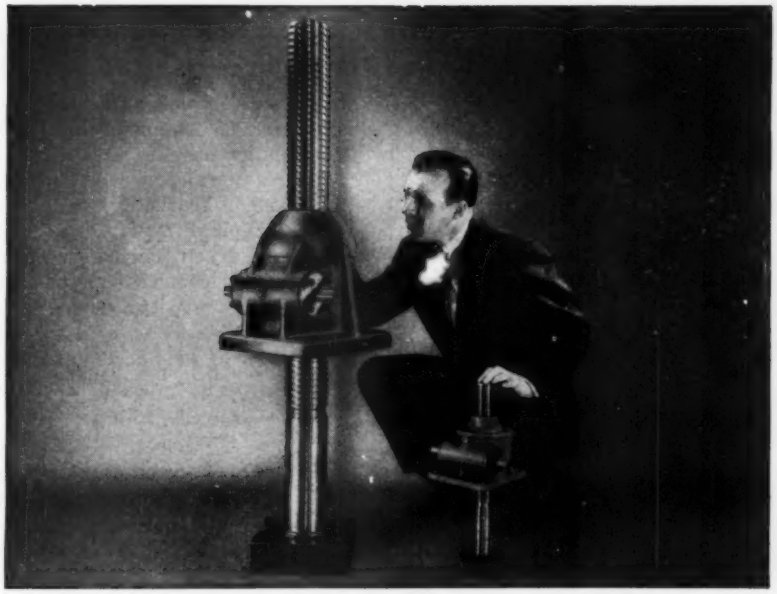
New Machines

Domestic

High-Fidelity System: Combination includes a phonograph and remote speaker. Power amplifier uses two stages of audio amplification, including push-pull output with power output of 6 w. Variable bass, treble and compensated-loudness controls are mounted on the outside of the cabinet. Three speakers are included in the basic cabinet—two front-mounted 6 x 9-in. oval speakers and a 5-in. high-frequency speaker, equipped with sound diffusers. Record changer plays intermixed records of different sizes of the same speed. It is equipped for automatic shutoff and has a heavy-duty four-pole, shaded-pole motor. Muting switch eliminates electrical noise during changing cycle. Remote speaker system includes two speakers—one 12-in. bass speaker and one 6 x 9-in. high-frequency speaker, equipped with sound diffusers. *Magnavox Co., Spartan Div., Ft. Wayne, Ind.*

Home Laundry Equipment: Five automatic washers and four electric dryers are included in a line of home laundry equipment. Water controls on the washers provide a choice of hot or warm wash water and warm or cold rinse water. Cold water rinse permits use of wrinkle-free washing techniques for synthetic fabrics. Bleach dispenser and measuring cup are located in the top of the agitator. Any operation of the washing cycle can be stopped, repeated, lengthened or shortened. Light loads of regular clothes or full loads of synthetic fabrics can be washed, rinsed and spin-dried in 12 minutes. Tubs are porcelain-finished. Dryers are equipped with a pedal-operated latch which permits opening the door 180 deg without using the hands. Clothes can be dried from 10 to 145 minutes in an infinite number of heats. Five-minute cooling period is provided automatically at the end of any cycle. Front and rear drum supports as-



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Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

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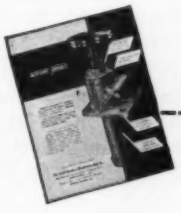

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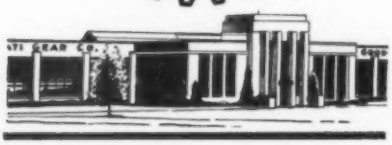

Circle 612 on page 19

New Machines

sure smooth operation. Heating units are sealed, shielded and screened for complete protection. Some units have a larger, hotter air stream which speeds the drying cycle. Washers and dryers are 36 in. high. Washers are 25 in. wide; dryers are 27 or 30 in. wide. They can be installed flush to the wall, and are available in pastel colors and white. *General Motors Corp., Frigidaire Div., Dayton, O.*

Metalworking

Contour Correcting Machine: New contour correcting and straightening machine corrects cross-sectional distortions of aluminum extrusions. The unit is designed for simple changeover to different extruded shapes, and employs multiple rolls of simple design. It is furnished with one or more contour-correcting stands with provision for additional stands. For simple shapes a single stand can be used. For more complex shapes, two or more stands make possible corrections in one pass. *Sutton Engineering Co., Pittsburgh, Pa.*

Grinding Machine: Heavy-duty unit grinds long members, either straight surfaces or long, curved irregular surfaces to template. The machine is a traveling-wheel type with work remaining stationary. Compound saddle mounted on the bed is moved longitudinally by means of a heavy-duty roller-type chain driven through sprocket and worm reduction by a variable voltage or reversing motor. The drives give a smooth flow of power at speeds up to 100 fpm. Grinding column on which the spindle is mounted can be moved 24 in. toward or away from work. Saddle can be moved vertically to provide approximately 48 in. vertical travel. Spindle is driven by a 30-hp motor at 1200 rpm. Any length of bed can be used. *Morton Mfg. Co., Muskegon Hts., Mich.*

Air Arbor Presses: Heavy-duty Vi-Speed air arbor presses are available in 16 models to 5 tons, either hand or foot controlled. Throat clearance is up to 6¾ in. with adjustable ram clearance to

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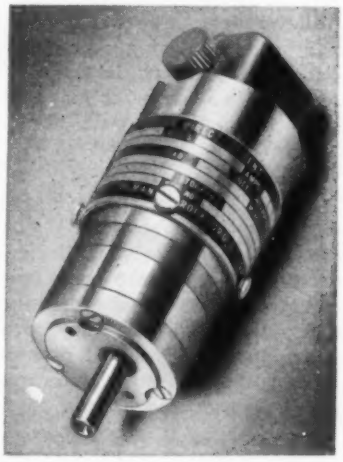
permanent magnet type with maximum torque output from 5 to 10 pound-inches



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Circle 613 on page 19

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12 in. Any stroke from a minimum of 2 in. to the maximum ram clearance is available. The presses are also used for riveting, forming, bending and press-fitting. Units up to 2 tons have 1½ in. OD rams; rams on larger units are 2 in. OD. Cylinders of similar bore sizes are stacked to increase power thrust. On double-acting stacked cylinders, only one cylinder is used for the return stroke, permitting a reduction in air consumption. *Van Products Co., Erie, Pa.*

Power Plant Equipment

Rectifier Power Source: Continuous duty 1540-amp rectifier power supply is rated for 100 per cent duty cycle for the submerged arc process. It is designed for operation on a three-phase, 460 or 575-v input and has an actual output range of 600 to 1600 amp. Drooping volt-ampere characteristic limits short circuit current. Input voltage is stepped down by three transformers with moving-coil design, and rectified by selenium rectifiers. Coils are motor-driven to provide remote current adjustment. Controls for contactor and current output are mounted on the cabinet, and both can be operated remotely. Unit is cooled by two propeller-type fans, powered by reversible, totally-enclosed 1/3-hp motors. Coils, with Class H insulation, are rated for 130 C temperature rise. Open circuit voltage is 78 v; at full load the output is rated 40 v. *General Electric Co., Welding Dept., Schenectady, N. Y.*

Diesel Engines: Model 40 Superior diesel engines are designed for use in heavy equipment such as power shovels, as standby power for industrial plants and telephone companies and mobile power for utilities. Portable engine generator sets range to 600 kw capacity. The units are built as four-cycle, six or 8-cylinder, vertical in-line engines. Output ranges from 215 to 1025 hp. Design features include improved open chamber combustion for fuel economy; redesigned intake and exhaust ports; dual fuel operation on 100 per cent oil, or natural gas with pilot fuel injection for ignition; cold

Aren't these the 5 things ENGINEERS want in their JOBS?

By—CHARLES E. CLEMINSHAW
Vice President, Engineering, Parker Aircraft Co.

In the past few years we have talked to scores of engineers of all ages, talents, and temperaments. We have talked to them about many things, but mostly about what they *wanted* in their jobs.

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2. SECURITY Some engineers seem to have "cancellation jitters" when they are working on a single large Government contract which may be cancelled or cut back at any time. The work at Parker is diversified. We design and build products for many customers—including every manufacturer of airplanes or engines. We are dedicated to a solid, long range growth in the field of "fluid handling." We specialize in fuel systems equipment, air control and regulating valves, hydraulic system components, and in research and development projects created by new fuels, higher temperatures, and the more complicated devices required on missiles and high speed jet aircraft.

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Please write me personally:

CHARLES E. CLEMINSHAW, *Vice-President,*
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Hydraulic and fluid system components

Circle 614 on page 19

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weather, heavy-duty compressed air starting system, and removable and interchangeable individual cylinder heads. *White Motor Co., Diesel Engine Div., Springfield, O.*

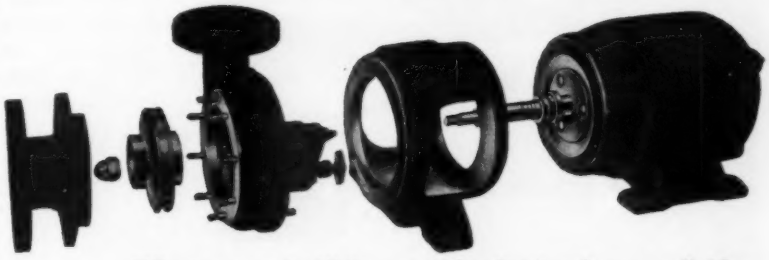
Processing

Hot Stamping Machine: Phenolic plates with copper circuits are marked in color with circuit identification or assembly numbers in an adaptation of Model 9AS hot stamping press. The machine counts, marks and ejects automatically all circuit plates placed in the magazine. The ejector replaces the marked plates in sequence in another magazine. Speed is 3600 marked plates per hour. Hand latch controls continuous or intermittent operation. The magazine is equipped with friction drive and the ejector has a force feed. The machine hot stamps in color any desired lettering and consecutive numbers. Pneumatic feeding unit is electrically operated from the ram. *Acromark Co., Elizabeth, N. J.*

Oven: New oven is designed especially for preheating acrylic materials prior to forming operations. It is electrically heated by a 35 kw system and has horizontal air flow. Fully loaded, it handles up to 150 lb of material. The interior is 48 in. wide, 72 in. deep and 12 in. high. Body is double-walled, separated by 4 in. of Rockwool insulation. Interior is of 22 gage oven steel. Two lift-type doors permit easy access to either end of the working chamber. Heating system consists of open-coil, low-gradient heating elements mounted in an insulated heater chamber at the top of the oven above work chamber. Dynamically and statically balanced belt-driven fan, rated 1400 cfm, is built into the heater chamber to provide air flow across materials. Indicating control with a range from 100 to 600 F operates with the electrical heating equipment to automatically control oven temperature within close limits. Exhaust vent is located on the roof. It is provided with an adjustable damper to control the amount of air exhausted. *Despatch Oven Co., Minneapolis.*

It's designed and built the way you would do it for

efficient liquid flow!



Glance at this exploded view of the

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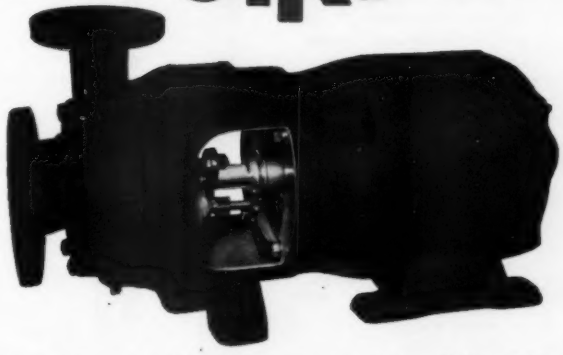
MOTORPUMP



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Circle 615 on page 19

ELCO SCREWS

Elco Screws are Good Screws

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PHILLIPS SCREWS

ELCO is one of the prominent sources for all types of "Phillips" Recessed-Head Screws. At ELCO particular care is taken to maintain the standardized specifications of the distinctive Phillips recess — for best performance and lowest handling cost on *your* assembly line. Many ELCO-PHILLIPS Screws are stocked for immediate delivery. *Write for our stock list.*

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MACHINE SCREWS
MACHINE SCREW NUTS
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THREAD-CUTTING SCREWS
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PIPE PLUGS
STOVE BOLTS
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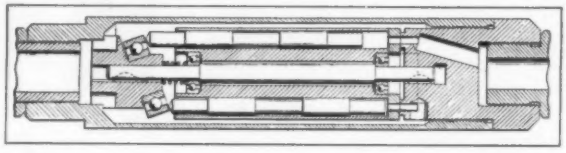
DRIVE SCREWS
SPECIAL SCREWS
COLD HEADED PRODUCTS

ELCO TOOL AND SCREW CORPORATION
1950 BROADWAY • ROCKFORD, ILLINOIS

NOTEWORTHY Patents

Hydraulic Flywheel

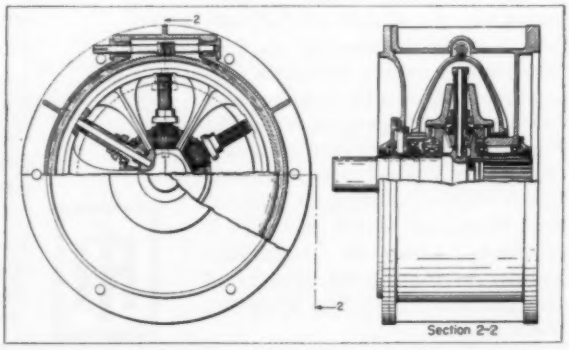
Fluctuations in fluid-flow rate between a hydraulic pressure source and a driven component are smoothed out by an energy-absorbing hydraulic flywheel. Designed for installation in the line between source and load, the unit comprises a fluid-driven rotor, which



rotates at high speed, and multiple, axially aligned pistons and cylinders. Swash-plate action of an inclined ball bearing causes the pistons to alternately draw fluid from the source line (right) and discharge it to the load line (left) as the rotor revolves. Pumping action stores fluid kinetic energy during transient periods of low fluid demand, releases energy during peak-demand periods. Flow of fluid and load on the pump motor is thereby maintained substantially constant despite any tendency of the driven component to require fluid at a variable rate. *Patent 2,743,581 assigned to Kobe Inc. by Clarence J. Coberly.*

Stepless Adjustable-Speed Transmission

Output-shaft speed can be held constant despite wide variations in input speed in a stepless, adjustable-speed transmission. Torque path is from the input shaft (left, Section 2-2) through the planet bevel gears to the ring gear and output shaft (right). Rotational speed of the bevel gears, and therefore the speed ratio, is determined by the radial position of rollers that frictionally engage a pair of axially movable disks. When the disks separate, rollers move radially outward under the action of centrifugal force, rolling over a longer path on the facing surfaces of the disks. Result is to maintain output speed constant regardless of changes in input speed. Interconnection of speed-changing elements, floating action of



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BARIUM
STEEL CORPORATION

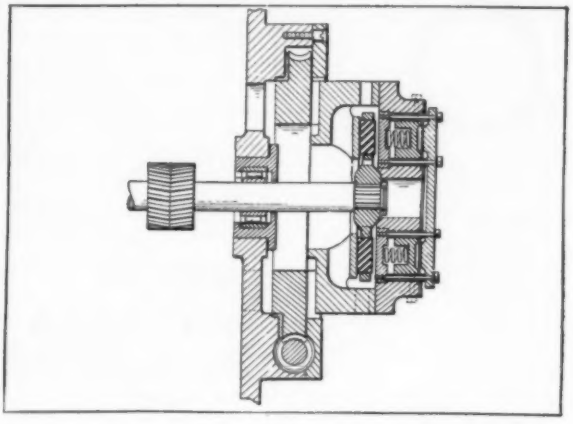
ERIE BOLT & NUT CO.
Erie, Pennsylvania
Representatives in Principal Cities

Noteworthy Patents

the disks, and symmetrical arrangement of transmission components minimize undesirable gyratory forces and vibrations. *Patent* 2,747,434 *assigned to Falk Corp. by Alfred G. Bade.*

Inching-Drive Assembly

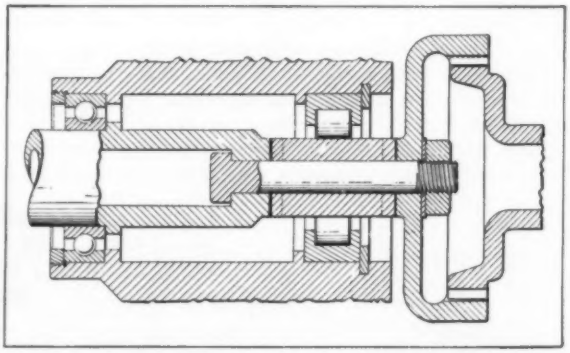
Accurate inching of power presses in either direction is provided by an inching-drive assembly which bypasses the press main drive motor and flywheel. When precise movement of the press ram is desired,



motion of a worm and gear, driven by a reversible auxiliary motor, is transferred to the press drive shaft by a friction clutch. It is not necessary to return the inching unit to any particular position before the press is again operated through its normal drive mechanism. *Patent* 2,755,687 *assigned to Danly Machine Specialties Inc. by James C. Danly.*

Bearing and Coupling

Designed for application where bearing-support housings are limited in inside diameter, a bearing and shaft coupling device utilizes a replaceable shaft



section as a bearing inner race. Because the shaft diameter can equal that of the conventional bearing inner race, torque capacity for a given housing size is increased. Multiple shaft sections, which are splined and bolted together, are driven by the internal ring and sun gear (right). *Patent* 2,754,163 *assigned to United Aircraft Corp. by Alexander H. King.*

THE SURPRISINGLY VERSATILE

HEIM Unibal

HAS MANY USES OTHER THAN STRICTLY ROD END APPLICATIONS

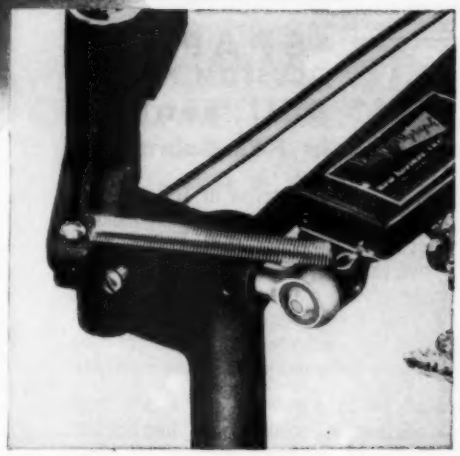
When a Rod End is *Not* a Rod End . . .

The Heim Unibal Rod End was originally designed to act as a self-aligning bearing terminal for push-pull rods. As a spherical bearing rod end, it has universal application and has solved many a linkage problem.

Many manufacturers discovered the versatility of the Heim Rod Ends and how inexpensively they could be applied as self-aligning supports for shafts, as superior pillow blocks, and as take-up bearings.

One example of how perfectly the Heim Unibal Rod End can be used for other than a push-pull linkage, is the New Hermes Engravograph, a machine for engraving watches, jewelry, silverware, and other articles with irregular surfaces.

Here two male rod ends are screwed into the casting to support the engraving arm. The rod ends make possible a smooth, dependable motion which compensates for misalignment and unevenness caused by irregularity of the working surface.



The male rod end is attached by drilling a hole in the work, tapping for proper thread fit, and screwing in the rod end.

The female rod end may be attached by drilling a hole in the work and drawing the rod end tight with a machine screw.

SEND FOR THE COMPLETE HEIM CATALOG NO. 100

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

Valve manufactured by Koehler Aircraft Products Company, Dayton, Ohio for use in North American Aviation, Inc., F-86 Sabre Jet.

SPARTA'S CUSTOM MOLDED TEFLON* Ball Seals

Control Air Flow in F-86 Sabre Jet!

The unique combination of properties of TEFLON, combined with Sparta's patented process of custom molding Teflon in Thin Sections and Shapes, engineered to meet exact requirements, permits a practical, economical solution to a critical problem in the manufacturing of the two Ball Seals used in this application. The motor-operated valve—as it is presently used—could not have been designed by employing ordinary flexible materials.

The two seals of Teflon are leak-proof, retain their original size—whether in contact with hydrocarbon fluids, water, air or other elements which would cause swelling in ordinary materials. The extremely low coefficient of friction enables the ball to rotate easily—opening or closing the valve.

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Flexible TEFLON Thin-Walled and Spaghetti Tubing . . . available in various sizes and colors.

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Circle 620 on page 19

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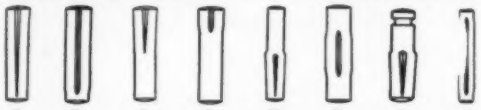

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SELF-GRIPPING • SELF-LOCKING

PATENT APPLIED FOR

P-M NUT

CUTS COST, SPEEDS ASSEMBLY . . . ELIMINATES WASHERS, WRENCHES

High-quality, low-cost nut is made of spring-tempered high carbon steel or of tempered aluminum. Has cut threads and a flange with turned-down corners which bite into material to which applied. Spring flange is deflected during tightening for vibration-proof assembly. Used by leading manufacturers. Available in sizes 6-32 through 10-32. Other sizes in process.

P-M ROLL-FREE DRAWN STEEL STUD

Effects unusual savings over solid studs for most roller mounting. Standard sizes in steel, stainless steel or brass or to your specifications.

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XUM

"MONOBALL" Self-Aligning Bearings

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CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-56.

SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA

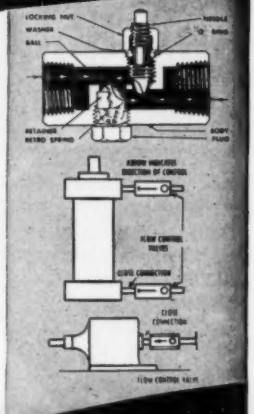
Circle 623 on page 19

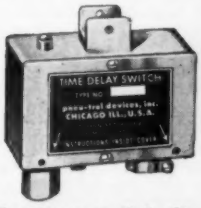
For Precise SPEED and TIME DELAY CONTROL

OF AIR OR HYDRAULIC CYLINDERS

USE **Pneu-trol** VALVES and TIME DELAY CONTROL SWITCHES

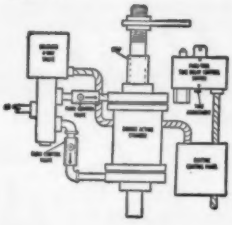
Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check valves and needle valves, incorporating single function features of Flow Control Valve are also available. All valves made in 5 female pipe sizes: ⅛" to ¾". Valve bodies made from brass, aluminum, steel or stainless steel.



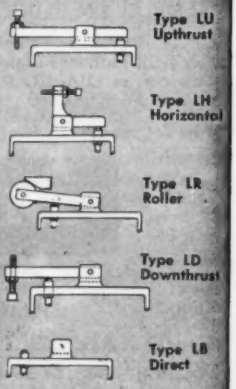


TIME DELAY CONTROL SWITCH FOR PRECISE DELAY OF WORK CYCLE

Provide controlled adjustable time dwell of solenoid operated air or oil supply valves. Range between ¼ and 60 seconds in 20 to 1 ratios. Compact—simple—foolproof—rugged Easily mounted on machine. Available for various types of actuation. Typical diagram below.



For Any Type Actuation Left or Right Hand (Left Hand Shown)



Write for catalogs and complete details

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Components for Automation
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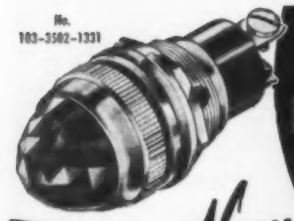
Circle 624 on page 19



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DUST TIGHT
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Exceptionally Rugged!

New
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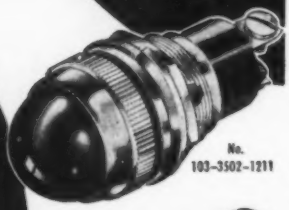
INDICATOR LIGHTS
for heavy duty use in industrial applications

Perfect oil-tightness is effected by retained oil-proof gaskets and the gasketed glass lens assembly . . . Install easily in a single 1" or 1-3/16" panel mounting hole. Also available for 11/16" mounting hole.



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A choice of *3 lens styles, 7 lens colors,* and other optional features provide adaptability.

DISCS with legends, behind flat lenses, deliver specific messages.

OIL TIGHT INDICATOR LIGHTS

accommodate a wide range of Incandescent and Neon Glow Lamps. For neon, DIALCO offers an exclusive feature — *BUILT-IN RESISTORS* (U. S. Patent No. 2,421,321) for operation on 105-125 V, or 210-250 V. Simple external resistors are provided for all higher voltages. *EVERY ASSEMBLY IS AVAILABLE COMPLETE WITH LAMP.* For design purposes we will gladly send you:

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CATALOG "L-200" gives you complete specs on DIALCO'S Oil-Tight Indicator Lights. Also available—a file of Special Catalogs on DIALCO Pilot Lights covering every indication requirement for automation and miniaturization.

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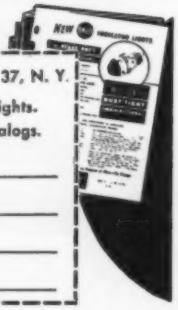

DIALIGHT CORP., 54 Stewart Ave., Brooklyn 37, N. Y.
☐ Please send Cat. "L-200" on Oil-Tight Lights.
☐ "Selection" brochure. ☐ Pilot Light Catalogs.
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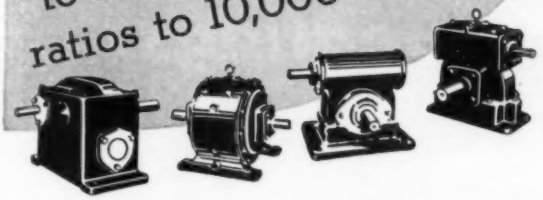
Abart SPEED REDUCERS — fractional to 168 hp. ratings . . . . . ratios to 10,000 to 1 . . .



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Compact, efficient Abart units last long, serve better and minimize maintenance. Spur, worm and combinations . . . single and double reduction types.

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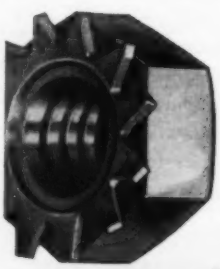
Circle 626 on page 19

FASTENERS by NATIONAL LOCK

"SEMS"

IN ALL TYPES, SIZES MATERIALS, FINISHES



Extensive facilities are coupled with long-term experience in the manufacture of all NATIONAL LOCK standard and special-purpose fasteners. You'll find this one-source supplier is capable, prompt and dependable in fulfilling your requirements. Write us.

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Registered Trademark of Illinois Tool Works.

NATIONAL LOCK COMPANY
Fastener Division • Rockford, Illinois

Circle 625 on page 19

Circle 627 on page 19

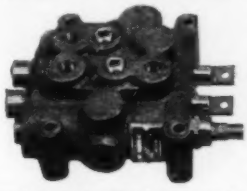
HUSCO

Doubles Production Capacity to Increase Availability of its Hydraulic Valves, Cylinders and Special Controls

Large new Husco plant addition, more than doubling our production capacity, reflects the increasing demand for Husco Products . . . A demand based on today's highest standards of engineering and performance.

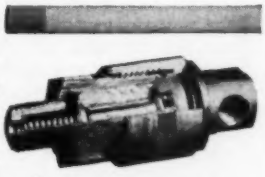
Primarily Engineered for Construction and Materials Handling Equipment, HUSCO Hydraulic Units are preferred for Their Space-Saving, Positive Operational Control and Cost-Saving Efficiency.

HUSCO HYDRAULIC CONTROL VALVES



Here is new engineered compactness in multiple-purpose valves that offer many advantages. Available in a full range of sizes with capacities from 6 to 60 G.P.M., in single-acting, double-acting and float position operational control, with from one to four cast-on-bloc plunger arrangements. Designed with fine throttling control in operating positions, they provide built-in adjustable relief valves and built-in check valves in operating circuit, and assure practically unrestricted flow through the valve. Available in either Series or Parallel circuits, with or without High Pressure Carry-over.

HUSCO ROTARY SWIVEL



Low cost, highly efficient Rotary Swivel designed for both high pressure and high operating speeds, particularly in the brake and clutch field. Compact, for use in close quarters. Has spring-loaded Teflon rings, self-centering ball thrust bearing, highly efficient axial bearings. Size, only 3" x 1½".

Check HUSCO first for modern hydraulic units. All HUSCO Standard Hydraulic Units can be custom-engineered to your specifications with speed and dependability. Write for details.

HUSCO

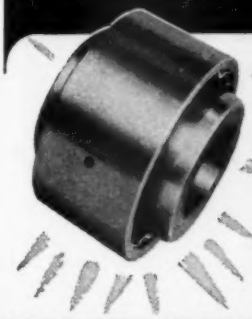
HYDRAULIC UNIT SPECIALTIES CO.

Hydraulic Pumps, Valves, Cylinders, Controls

AIRPORT ROAD, WAUKESHA, WIS.

Circle 628 on page 19

YOU GET 6 WAY SAVINGS



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1 LOWER INITIAL COST

Size for size, Sier-Bath costs average 21-percent lower than other leading brands . . . as horsepower loads go higher, Sier-Bath costs go lower!

2 SAVINGS IN SPACE AND WEIGHT

Smaller by as much as 40-percent over conventional flange and bolt types! Lighter weight, smaller size, lower inertia!

3 HIGHER LOAD CAPACITIES

In all types and sizes capacity is higher . . . from 4 to 4500 hp/100 rpm. Stock sizes range from ⅞ to 12 in all models.

4 STRONGER, LONGER LASTING

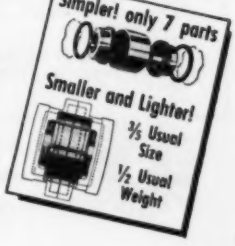
Hubs and sleeves have 90,000 pounds tensile strength and neoprene seals are guaranteed leakproof! Sleeves and hubs are interchangeable in same sizes.

5 SAVE ON ASSEMBLY COSTS

Use of snap rings instead of bolts means less coupling and uncoupling time . . . so simple a screwdriver is all you need . . . works with ease even after years of use!

6 SAVE ON EQUIPMENT WEAR

Accurately machined teeth of sleeves and hubs permit flexibility to take up misalignment . . . no binding . . . no motor burn-outs.



Fast delivery on standard or special types. The full story is in our Catalog C-4. Yours for the asking.

Sier-Bath

GEAR and PUMP CO., INC.

9254 Hudson Blvd., North Bergen, N. J.

Founded 1905 Member A.G.M.A.

Circle 629 on page 19

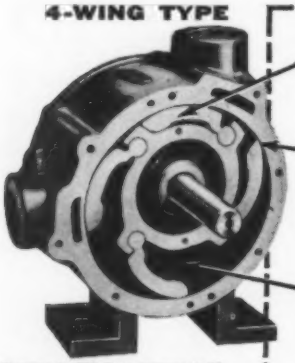
Exclusive Features of

LEIMAN Rotary Air and VACUUM PUMPS

bring you

★ High Vacuum
★ Greater Volume
★ Smaller Size
★ Lifetime Operation

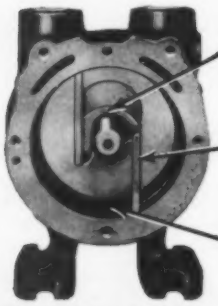
4-WING TYPE



- Curved Wings on easy-action hinge, maintain continuous wall contact.
- Cast Iron Wings and Cylinders hone themselves to hard, glassy smoothness—take up their own wear—assure leak-proof seal for years.
- Extra-large Air Space provides greater capacity, permits use of smaller pump.

Vacuums to 20" Hg.; pressures to 15 psig.; displacement to 162 c.f.m.

2-WING TYPE



- Automatic Wing Adjuster assures wing-to-wall contact, prevents sticking, guarantees positive action.
- Extra-long Steel Wings (not composition) provide long wear. Cylinder walls made of durable cast iron.
- Large air space provides more compact pump.

Vacuums to 29.9" Hg.; pressures to 20 psig.; displacement to 40.8 c.f.m.

Install LEIMAN AIR PUMPS

for dependable Vacuum (Suction) and Pressure

FREE ENGINEERING DATA

- *Application Book* showing 60 "how-to-do-it" blueprints of actual applications.
- *16-page Catalog* showing construction, types, sizes, capacities, etc.

Precision-made, compact Leiman Air Pumps have fewer moving parts — no tips or blades to renew — need no maintenance except occasional oiling — run for 10, 15 and 20 years without trouble or shutdown. Over half a million installed. Consult our engineers on any air application.

SEE OUR CATALOG IN SWEETS FILE

LEIMAN BROS., Inc.

148 Christie St., Newark 5, New Jersey

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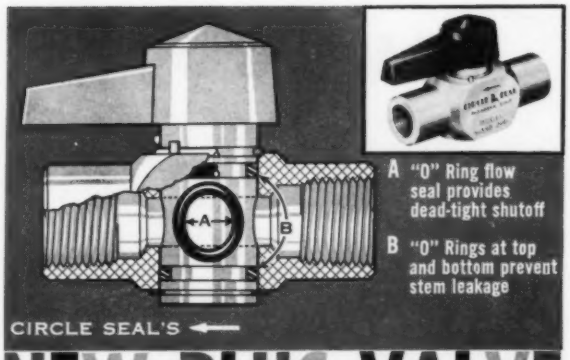

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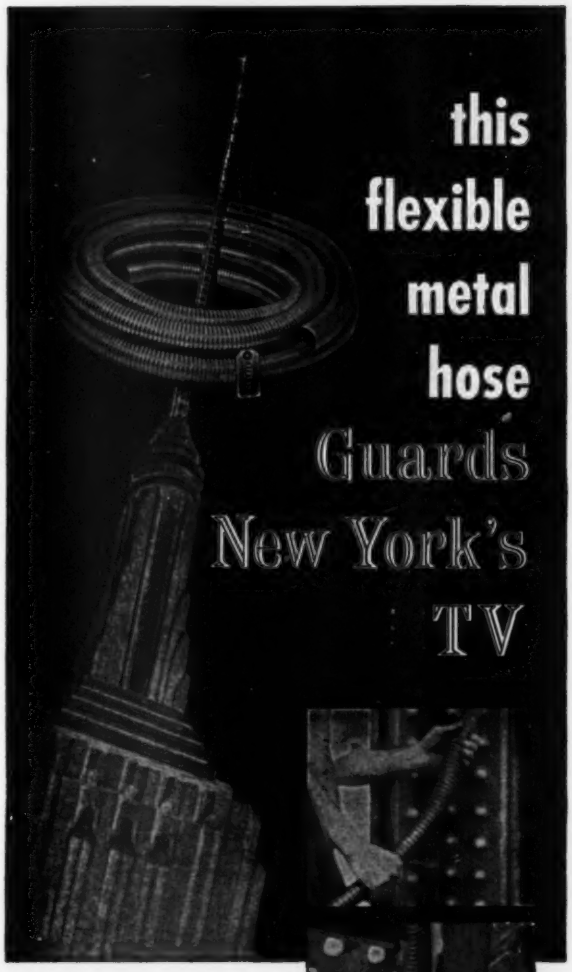
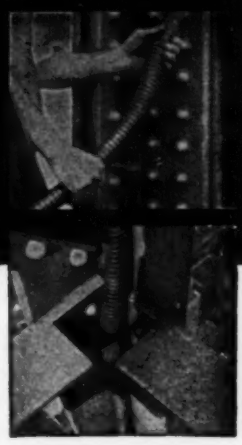


this flexible metal hose Guards New York's TV



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Circle 635 on page 19

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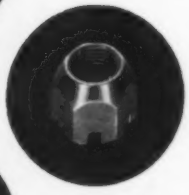
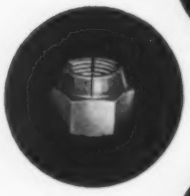
SPECIAL  HEXAGON NUTS TO YOUR SPECIFICATIONS



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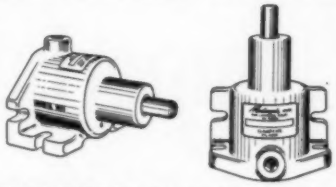

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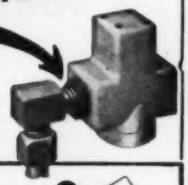

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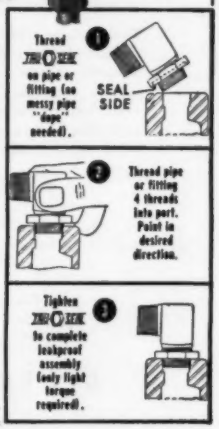
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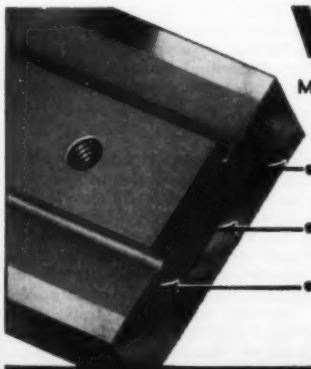

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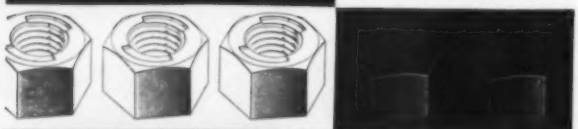

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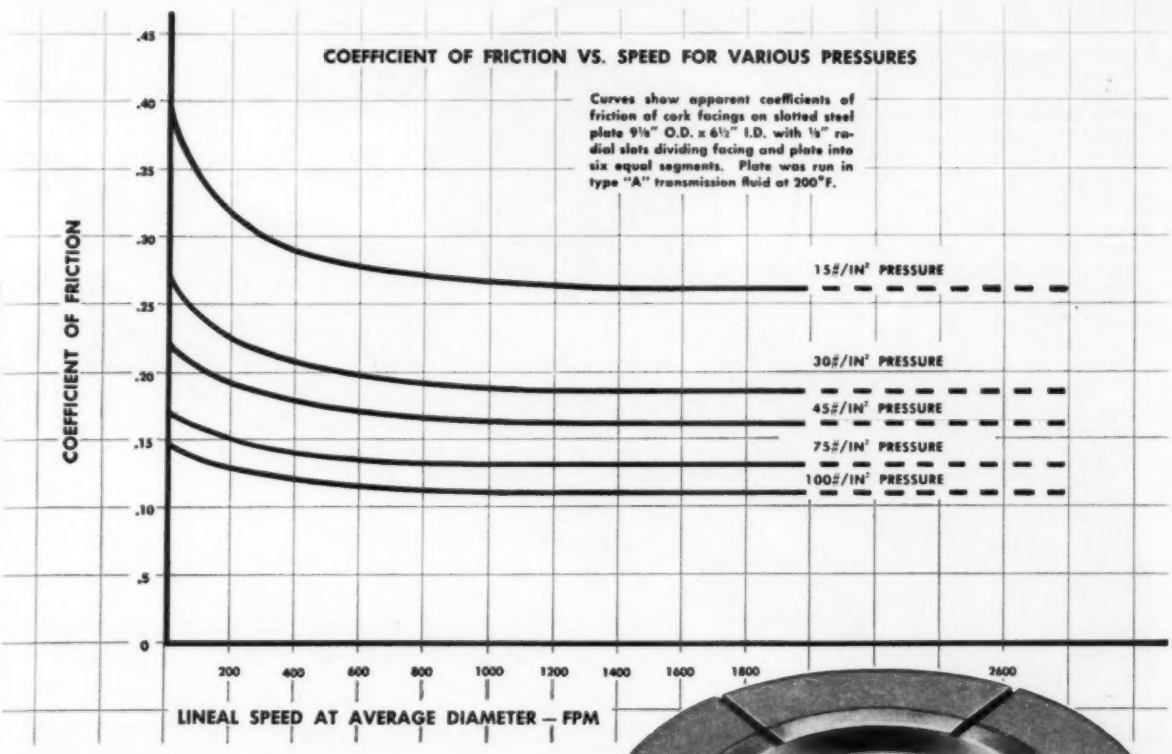
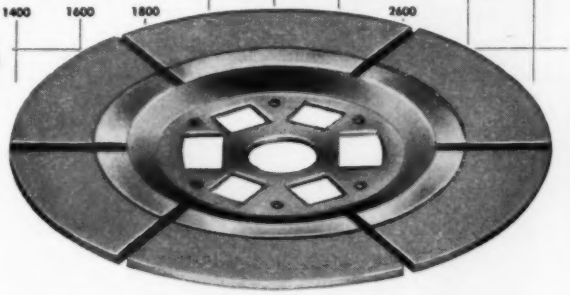




CORK CLUTCH FACINGS:

High torque capacity at low engagement pressures

The ability of cork facings to work efficiently at low engagement pressures helps clutch manufacturers get high torque capacity at relatively low cost. Savings in the number of plates or their size are often possible—and, in turn, savings in weight, space, metal, and friction material.

The chart above shows that a typical cork-compound clutch facing has relatively high coefficients of friction under engagement pressures as low as 15 psi. This kind of performance makes cork composition facings ideal for use in tractors, appliances, and industrial equipment, for example, where unit pressures of 20 psi to about 150 psi are normal.

The life expectancy of cork is amazingly long. In fact, Armstrong cork clutch facings in the automatic transmissions of 13 American makes of automobiles normally outlast the cars themselves.

Another design advantage of cork facings is the wide performance range that can be obtained by changes in the plate design or the cork compound itself. This flexibility gives designers wide freedom in clutch design which is of value whether their goal is cost reduction or performance improvement.

Perhaps cork's high torque capacity and dependable performance can be of help in your clutch design problems. We'll gladly help you choose the most efficient cork facings for your particular applications. Write to Armstrong Cork Company, Industrial Division, 7211 Dean Street, Lancaster, Pennsylvania.

Armstrong FRICTION MATERIALS

. . . used wherever performance counts

Circle 645 on page 19

XUM

REVERE COPPER EXTRUSION shown attached to skirtboard before full assembly, which you can see below in exploded view. A matching bar, similar to the one shown is part of the "packaged" HANCO unit and is fastened to the opposite side of the screen. Units, in turn, are installed on the various types of Vibrating Screens made by HEWITT-ROBINS INC., Passaic, N. J., and are known as the HEWITT-ROBINS HANNON Electric Screen Heaters.

CLOSE-UP showing end of the Revere Copper Extrusion.

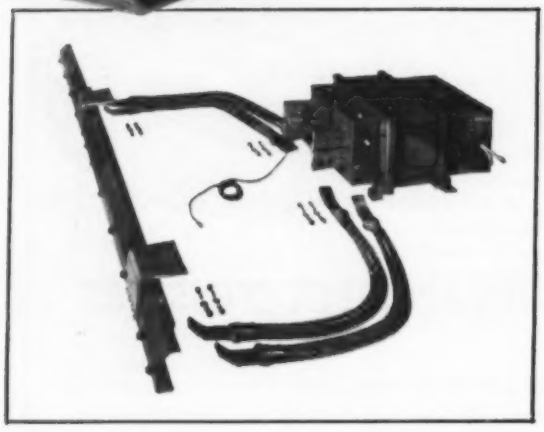
Revere Copper Extruded Shape

in Hanco Electric Screen Heater

out-performs

former copper casting

on 4 counts



"Customers of F. R. Hannon & Sons are now assured of many years of maintenance-free performance plus improved products."

Says T. W. HANNON, *Vice-President, General Manager*
F. R. HANNON & SONS, Canton, Ohio

Mr. Hannon continued, "For a number of years we had experimented with many different types of materials which would be non-porous, free from any burrs or voids, capable of maintaining a straight leading edge and able to carry 1500 amperes at 5 volts. The Revere Copper Extrusion meets these requirements. And for the rugged use to which our machines are put it would be virtually impossible to maintain satisfactory operating results without the use of this extruded electrical conductor."

Perhaps there is a Revere Product that can help you give *your* customers a superior product, or help cut your production costs. You'll never know until you call the Revere Office nearest you and ask to have a T. A. (Technical Advisor) call. Why not make that call today?

Here's the Score!

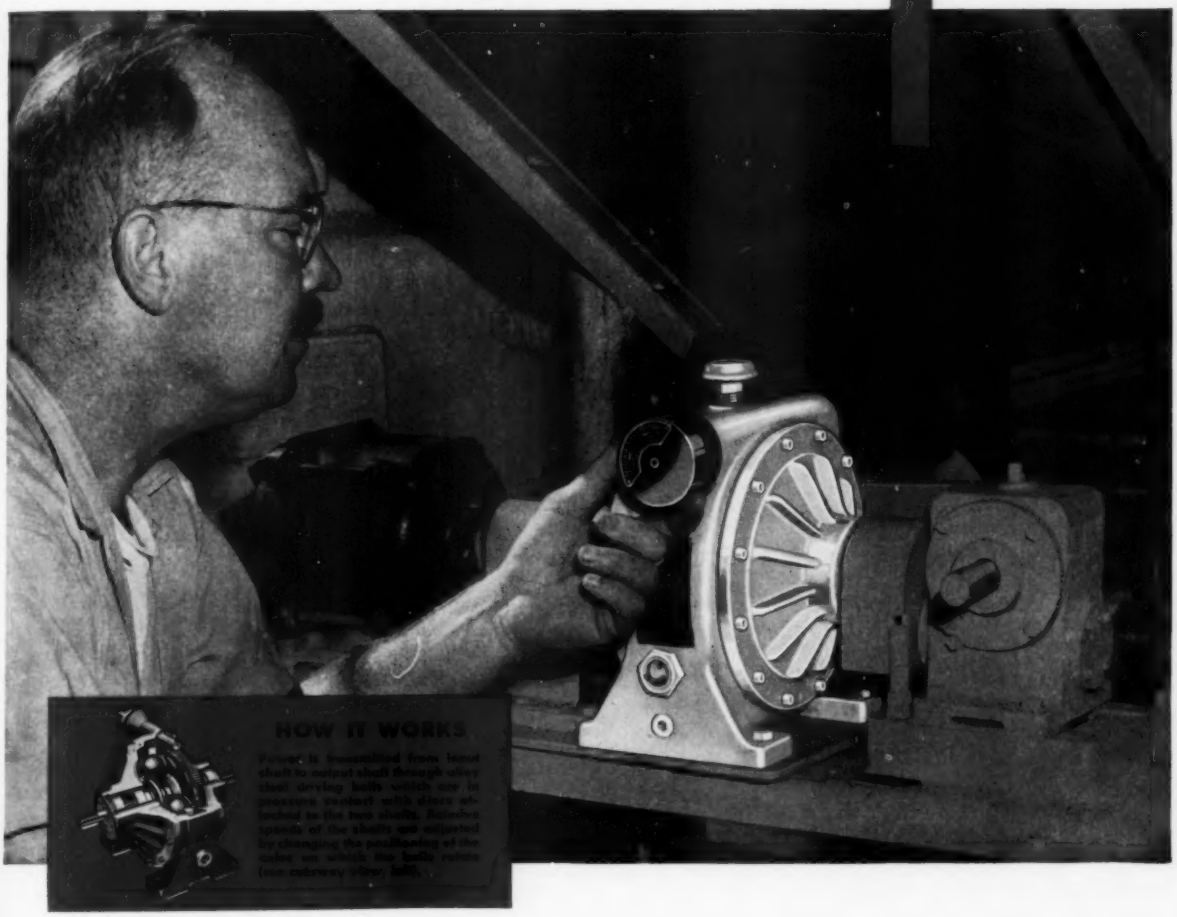
COPPER EXTRUDED SHAPE	COPPER CASTING
1—12 foot mill lengths offer flexibility, eliminating both welds and scrap	1—60" casting required additional welded joints
2—Shape offers lack of porosity	2—Casting gave porosity problem
3—Shape straightness is superior to casting, giving better electrical contact	3—Bow in casting presented difficulty when fastening screen firmly to contact
4—Higher cost per foot, but cheaper over-all installation	4—Initial cost was lower, but additional welds and scrap resulted in higher final cost, and an inferior finished product

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.
Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y.
Sales Offices in Principal Cities, Distributors Everywhere.

COPPER ★ BRASS ★ 1801 ★ REVERE ★ ALUMINUM

Major chemical producer meters flow of catalytic agents with Cleveland Speed Variator

A chemical research worker adjusts the manual control knob on the Cleveland Speed Variator to set the metering speed. Various types of regulating mechanisms can be mounted on the Variator to provide automatic adjustment by remote control.



IN the research department of a major chemical plant, catalytic agents are metered and their flow varied with precision accuracy. This control is exercised with a Cleveland Speed Variator.

A ¼-horsepower electric motor is connected to the Cleveland Speed Variator driving a pump through a 25-1 speed reducer. Being infinitely variable, the Variator gives stepless speeds over its full 9:1 range—from ⅓ to 3 times input speed. Pumping speed can be varied from 207 to 23 rpm. This provides the necessary speed range for metering the various types of catalytic agents.

Available in eighteen standard types and sizes, the Cleveland Speed Variator offers these major advantages: 1. An extremely compact unit; 2. Almost any input speed up to 1800 rpm—clockwise or counterclockwise; 3. Constant horsepower output over a 9:1 range, or constant output torque with a 6:1 range; 4. Infinitely variable over entire speed range; 5. Rapid response to speed change, precise adjustment, accurate maintenance of settings; 6. Long life and minimum maintenance; 7. Ample bearing support for overhung pulleys on either input or output shafts.

Write for Bulletin K-200 for detailed description of the Cleveland Speed Variator, with photographs, sectional drawings, rating tables and specifications.

THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3287 East 80th St., Cleveland 4, Ohio

Sales representatives in all major industrial markets. In Canada—Peacock Brothers Limited.

Circle 502 on page 19

XUM

Again and Again and Again

THE CHOICE OF THE LEADERS
THE MARK OF BETTER MACHINES

W. F. & John Barnes, a leading builder of machine tools and automation installations, standardizes on the use of Cutler-Hammer motor control equipment

Barnes Multiple Station "Progress-Thru" Machine which performs a total of 54 operations on automotive cylinder heads in a continuous automatic cycle. Cutler-Hammer Three-Star Motor Control and Heavy Duty Oil-Tight Pushbuttons are standard original equipment.

The W. F. & John Barnes Company, Rockford, Illinois, has designed and built highly specialized mechanical, electrical and hydraulic equipment and machines for more than 80 years. Their unusually competent Electrical Division has repeatedly won distinction in the custom designing and building of complex electrical control systems, particularly in advanced automation engineering. Their choice of Cutler-Hammer Three-Star Motor Control and Cutler-Hammer Heavy Duty Oil-Tight Pushbuttons, in their own words, "simply reflects our conviction that these are the very best available."

Cutler-Hammer Three-Star Motor Control and Cutler-Hammer Heavy Duty Oil-Tight Pushbuttons are the decided preference of able engineers whenever selection is determined by careful comparison. To be sure, you too should standardize on Cutler-Hammer . . . the choice of the leaders, the mark of better machines.

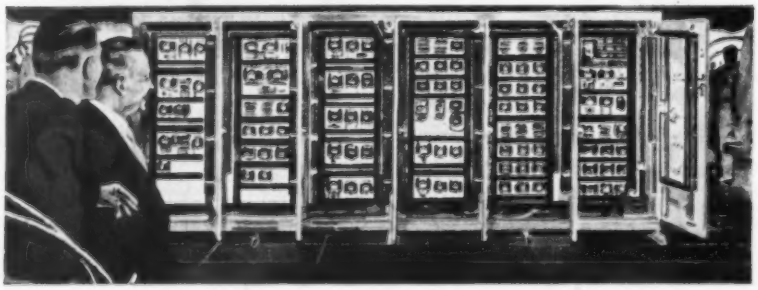
CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

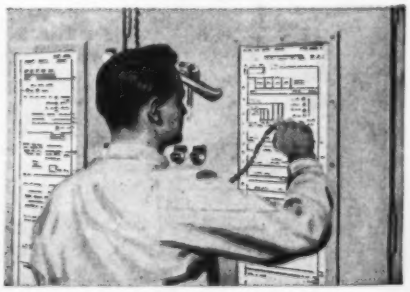
N. P. Bashor, Manager, Electrical Division, W. F. & John Barnes Company, recognized as an authority on machine tool control, says, "We are forever seeking improved techniques and equipment for Barnes machines. The extent to which we have standardized on Cutler-Hammer Three-Star Motor Control and Cutler-Hammer Heavy Duty Oil-Tight Pushbuttons simply reflects our conviction that these are the very best available."

CUTLER-HAMMER
MOTOR CONTROL
C-H

Control systems for Barnes machines include the unique Barnes Electro-Graphic Detector which can cut trouble-shooting time as much as 90%. Detector circuits permit simple, speedy and safe pinpointing of any operating difficulties. With this detector, plant electricians do not have to be machine designers to be experts in supervisory maintenance.

Control cabinet doors of Barnes machine opened to show array of Cutler-Hammer Three-Star Motor Control components used.





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